PB88-192687

National Dioxin Study
Report to Congress

(U.S.) Environmental Protection Agency
Washington, DC

Aug 87

U.S. Department of Commerce
National Technical Information Service
NTIS

BIBLIOGRAPHIC INFORMATION

PB88-192687

National Dioxin Study - Report to Congress.

Aug 87

PERFORMER: Environmental Protection Agency, Washington, DC.
Office of Solid Waste.
EPA/530/SW-87/025

The report presents the results of EPA's investigation of potential 2,3,7,8-TCDD ('dioxin') contamination. The report also includes information on chemical reactions and on sources and pathways of human exposure.

KEYWORDS: *Air pollution, *Combustion products, *Dioxins.

Available from the National Technical Information Service,
SPRINGFIELD, VA. 22161

PRICE CODE: PC A08/MF A01

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA/530-SW-87-025	2.	3. Recipient's Accession No. PB88 192687/AS
4. Title and Subtitle National Dioxin Study			5. Report Date August 1987
			6.
7. Author(s) Office of Solid Waste			8. Performing Organization Rept. No.
9. Performing Organization Name and Address U.S. EPA Office of Solid Waste 401 M Street, SW Washington, DC 20460			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address Same as box 9.			13. Type of Report & Period Covered Report to Congress
			14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This report presents the results of EPA's investigation of potential 2,3,7,8-TCDD ("dioxin") contamination. The report also includes information on chemical reactions and on sources and pathways of human exposure.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement RELEASE UNLIMITED	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 172
	20. Security Class (This Page) UNCLASSIFIED	22. Price

(See ANSI–Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4–77)
(Formerly NTIS–35)
Department of Commerce

PB88-192687

United States
Environmental Protection
Agency

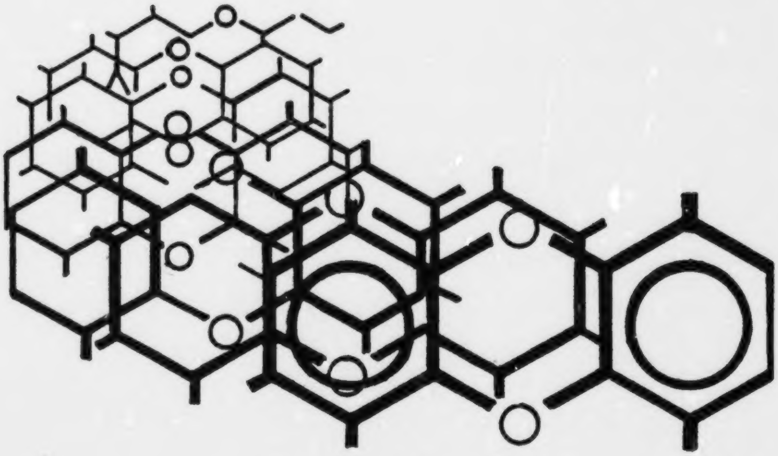
Office of Solid Waste
and Emergency Response

August 1987
EPA/530-SW-87-025

Solid Waste

EPA

National Dioxin Study



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National Technical Information Service
SPRINGFIELD, VA. 22161

NATIONAL DIOXIN STUDY

REPORT TO CONGRESS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Solid Waste and Emergency Response

August, 1987

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GLOSSARY

In general, we have tried to use the more precise term 2,3,7,8-TCDD (defined below) when discussing the particularly toxic "dioxin" associated with Times Beach, Missouri, Love Canal, and Agent Orange. The terms CDD/CDF refer to the entire class of chemicals of interest. CDD/CDF, a term which is also occasionally used in the text, is synonymous with dioxins/furans. When a specific isomer (individual chemical) other than 2,3,7,8-TCDD is referred to, it will be identified by means of the standard nomenclature outlined below.

The following defines, for purposes of this report, a few of the more commonly used technical terms.

Chlorinated dibenzo-para-dioxin/Chlorinated dibenzofuran (CDD/CDF) - any member of the family of chlorodioxins and related furans having one to eight chlorine substituents

Congener - any of the 75 CDDs or 135 CDFs

Homologue group - a group of chemicals that have the same degree of halogenation
For example, the homologous class of tetrachlorodibenzo-*p*-dioxins (TCDD) consists of those PCDDs which have four chlorine atoms.

Isomer - a particular member of a homologous group
E.g., 2,3,7,8-TCDD is the tetra- isomer which has chlorine atoms at the 2-, 3-, 7- and 8-positions.

2,4,5-T - 2,4,5-Trichlorophenoxy acetic acid

2,4,5-TCP - 2,4,5-Trichlorophenol, a basic chemical used to make a number of herbicidal products including 2,4,5-T, Silvex, Erbon, and Ronnel

RCRA - Resource Conservation and Recovery Act (as amended by the Hazardous and Solid Waste Amendments of 1984)

TSCA - Toxic Substances Control Act

FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act

CAA - Clean Air Act

CWA - Clean Water Act

CDC - Centers for Disease Control

FDA - Food and Drug Administration

NIOSH - National Institute of Occupational Safety and Health

EXECUTIVE SUMMARY

Study Design

EPA conducted a two-year nationwide study to investigate the extent of dioxin (2,3,7,8-TCDD) contamination. EPA also developed and implemented a National Dioxin Strategy to provide a coordinated management framework for investigative, remedial, and regulatory activities.

The nationwide investigation consisted of seven "tiers" with roughly decreasing expectation of finding 2,3,7,8-TCDD contamination:

Tier 1 -- 2,4,5-trichlorophenol (2,4,5-TCP) production sites (and associated waste disposal sites)
Tier 2 -- Sites where 2,4,5-TCP was used as a precursor to make pesticidal products (and associated waste disposal sites)
Tier 3 -- Sites where 2,4,5-TCP and its derivatives were formulated into pesticidal products
Tier 4 -- Combustion sources
Tier 5 -- Sites where pesticides derived from 2,4,5-TCP were used
Tier 6 -- Production sites for other chemicals where 2,3,7,8-TCDD formation may have occurred
Tier 7 -- Background (urban/rural soil, fish samples)

For combustion sources, EPA also tested for the presence of other isomers of dioxins and furans, as previous testing had shown significant levels of these other compounds.

Results

In its investigatory and cleanup efforts at Tier 1 and 2 sites EPA identified twenty-one 2,4,5-TCP related production facilities (tiers 1 and 2) and 79 associated waste disposal sites (tiers 1a and 2a), considerably fewer than original projections of as many as 50 production sites and 400-500 disposal sites.

As expected, these sites had the highest levels and greatest quantities of 2,3,7,8-TCDD. Most of the sites are traditional production and disposal facilities. The widespread dispersal of dioxin-contaminated material that occurred in Missouri (47 of 79 total disposal sites) was not identified elsewhere.

In most cases the dioxin (2,3,7,8-TCDD) has not migrated off-site. However, in those cases where it has, extensive environmental problems usually resulted, e.g., at Vertac, Love Canal, and Hyde Park. A mix of federal, state and responsible party actions are underway to seek necessary corrective actions. Emergency measures to protect public health have been successfully implemented wherever necessary. Permanent remedies are proceeding at a slower pace because of the complexities involved.

With the exception of two large facilities that handled 2,4,5-TCP, 2,4,5-T and/or Silvex, soil at pesticide formulators (tier 3) was not found to be extensively contaminated above the 1 ppb level. 2,3,7,8-TCDD was generally detected in only 1 or 2 samples at a given site. Regional offices are following up at 17 large formulators that handle these materials, which were not originally selected for sampling.

2,3,7,8-TCDD was detected at greater than 1 ppb in soil samples at 10 of the 64 pesticide formulator facilities sampled, and at less than 1 ppb at 9 additional sites. At 2 sites, 2,3,7,8-TCDD was detected at low ppt levels in fish or sediment. 2,3,7,8-TCDD was not detected at 43 of the 64 sites.

2,3,7,8-TCDD was found more frequently at 2,4,5-T and Silvex use sites (tier 5) than at "background" sites (tier 7). Soil and sediment contamination detected at 15 of the 26 use sites sampled was generally in the low parts per trillion (ppt) range. The principal exception was a site where samples were taken at a herbicide mixing/loading area.

'Other' chemical plants (tier 6) do not appear to be extensively contaminated at levels of concern. 2,3,7,8-TCDD levels greater than 1 ppb were detected at 3 of the 18 facilities sampled. Three had levels below 1 ppb and 12 were non-detected.

2,3,7,8-TCDD was found infrequently in urban and rarely in rural 'background' soils at the ppt level.

2,3,7,8-TCDD contamination in fish has previously been reported by EPA and others. Such contamination was generally linked to chemical industry activity or waste disposal. National Dioxin Study activities have identified fish contamination thought to be associated with chemical industry activities as well as contamination possibly associated with the pulp and paper industry.

2,3,7,8-TCDD was detected in fish composite samples at 112 of the 395 sites sampled. While levels were as high as 85 ppt in whole fish and 41 ppt in filets, only four sites had levels above 25 ppt, one of which was in a filet. 2,3,7,8-TCDD was detected in 23 of 29 Great Lakes fish samples.

Fish advisories for 2,3,7,8-TCDD had been in effect prior to the study for a number of areas such as the Tittabawassee River in Michigan. Advisories were in effect for the Great Lakes due to contamination from mirex, PCBs and mercury.

As a result of the study, advisories to limit fish consumption have been issued by the States of Maine for the Androscoggin River at Lewiston; Minnesota for the Rainy River; and West Virginia for the Kanawha River at Nitro, WV.

Outside of the Great Lakes, fish contamination was primarily found in major river systems, such as the Ohio and Mississippi River, or in waterways with significant industrial activity. The initial focus of EPA followup is on pulp and paper and chemical industry discharges.

Earlier investigations of municipal waste combustors (MWCs) had revealed that combustion sources emit dioxins and furans. EPA stack tested 13 additional sources in various source categories ranging from secondary copper smelters to wood stoves. The sources tested emit CCDs/CDFs, although generally at very low levels. Secondary copper smelters and sewage sludge incinerators have the highest estimated ground level concentrations of the sources tested under tier 4. EPA has prepared a separate report to Congress on risks from emissions and proper design and operation of MWCs.

Regulatory Activities

EPA has initiated a number of regulatory activities to control the generation, use and disposal of dioxin-contaminated materials to prevent future contamination. The Agency has:

- Imposed stringent management and disposal requirements by listing certain dioxin-contaminated wastes as acutely hazardous under RCRA, and providing for eventual banning of such wastes from land disposal unless they are first treated.
- Cancelled uses of the pesticide 2,4,5-T, a principal ingredient in Agent Orange.
- Placed additional restrictions on continued use of PCB transformers. These requirements are intended to protect building occupants, emergency response personnel and others from exposure to CDDs/CDFs generated during PCB fires.
- Under FIFRA, imposed additional use restrictions, handling requirements, and product contaminant level reduction requirements on wood preservative uses of pentachlorophenol (PCP), inorganic arsenical compounds and creosote. (It has been shown that PCP contain CDDs/CDFs.)

EPA has also initiated rulemaking under TSCA to identify additional products and industrial waste streams which may be contaminated, and is evaluating waste streams from PCP wood treatment operations for possible hazardous waste designation. OAR is assessing whether to list CDD/CDF as a hazardous air pollutant under Section 112 of the Clean Air Act.

Research

EPA has successfully field tested its Mobile Incinerator System in Missouri. The unit demonstrated a 99.9999 percent destruction and removal efficiency (DRE) for liquid waste and for contaminated soil. EPA has also used a chemical process, polyethylene glycol (KPEG), to decontaminate a mixture of diesel oil and PCP pumped from groundwater at a Superfund site in Montana. EPA is investigating other promising treatment technologies as well as conducting research in the areas of monitoring, analytic methods, environmental effects and health assessment.

EPA efforts are coordinated closely with FDA, CDC and NIOSH, and with international entities through the NATO CCMS (Critical Challenges Facing Modern Society) program.

Chapter One

INTRODUCTION

This report presents the results of EPA's investigation of potential 2,3,7,8-TCDD ("dioxin") contamination. The study was a two-year, nationwide, multimedia evaluation initiated at the request of Congress in House Report 98-223 accompanying the bill making appropriations for the Department of Housing and Urban Development and for other independent agencies for FY'1984 (HR 3133). EPA headquarters and regional staff, plus state personnel from a variety of program offices, contributed significant time and resources to the effort. This report is a summary of information contained in more detailed reports prepared by individual program offices (EPA, 1987b, c, d).

1.1 Basis of Public and Congressional Concern

Numerous incidents of contamination/exposure at home and abroad coupled with the high toxicity and persistence of 2,3,7,8-TCDD have resulted in a high level of public awareness and concern. This concern carries over into present efforts to implement cleanup actions and conduct disposal operations.

Among the best known incidents was the exposure of U.S. servicemen to Agent Orange in Viet Nam (1966-1971). A defoliant, Agent Orange was contaminated with 2,3,7,8-TCDD. A large class action suit was filed on the basis of alleged health effects.

In Seveso, Italy, a 1976 industrial accident involving 2,4,5-trichlorophenol (2,4,5-TCP) manufacturing resulted in widespread, low-level 2,3,7,8-TCDD contamination. This resulted in evacuation of parts of the community, animal deaths, and extensive cleanup efforts. Approximately 175 cases of chloracne and dermatitis, many of which were acute effects due to exposure to chlorophenols and chlorobenzenes, were confirmed.

Mild chloracne has been observed in humans in Nitro, West Virginia for at least a decade after exposure to industrial chemicals containing 2,3,7,8-TCDD.

In the early 1970's, waste oil contaminated with 2,3,7,8-TCDD was used to control dust on roads in Times Beach, Missouri. The eventual result was the well-known government 'buy-out' of the town. Use of waste oil at several Missouri horse arenas resulted in human health effects and the death of 65 horses. Subsequent use of the excavated horse arena materials as fill at building sites resulted in a proliferation of cleanup problems.

2,3,7,8-TCDD and other chemical contamination of adjacent land and water resulting from industrial waste disposal at Love Canal and Hyde Park in New York posed health risks. Efforts to limit the spread of this contamination continue today. 2,3,7,8-TCDD contamination resulting from 2,4,5-TCP manufacture and waste disposal was also found to be extensive, both on- and off-site, at the Vertac facility in Jacksonville, Arkansas.

In 1979, investigations at a municipal incinerator in Hempstead, New York, led to the discovery that CDDs/CDFs were being emitted during the combustion process. This information supplemented European reports of CDD/CDF emissions from such facilities, and a later Dow Chemical Company report of emissions from numerous combustion sources.

In 1980, a PCB transformer fire in the basement of a state office building in Binghamton, New York, resulted in distribution of soot containing dioxins and furans, including the 2,3,7,8-isomer, throughout the building. Cleanup costs to date have exceeded the original construction cost of the building.

In 1981, reports from Canada revealed the presence of 2,3,7,8-TCDD in Great Lakes fish. These reports coincided with reports of fish contamination in several U.S. rivers, notably the Tittabawassee River in Michigan.

In response to the public concern generated by these incidents, Congress requested that EPA initiate an investigation.

1.2 The National Dioxin Strategy

At the time of the Congressional request for a study, EPA was in the midst of responding to contamination in Missouri and other locations. The Agency also had rulemaking proceedings underway in a number of offices. To provide a coordinated management framework for the numerous dioxin-related activities throughout the Agency, EPA developed and implemented a National Dioxin Strategy. The Strategy describes the full range of activities planned or underway to address various aspects of the dioxin problem (EPA, 1983).

1.2.1 Objectives

EPA's National Dioxin Strategy had three objectives:

1) study the extent of dioxin contamination and the associated risks to humans and the environment;

2) implement or compel necessary cleanup action at contaminated sites; and

3) further evaluate both disposal alternatives to alleviate current problems, and regulatory alternatives to prevent future contamination.

1.2.2 Management

The Assistant Administrator, Office of Solid Waste and Emergency Response, was responsible for implementing the strategy. The Deputy Director, Office of Solid Waste, was designated Dioxin Management Coordinator. Virtually every program in the Agency has played a major role. The Dioxin Management Coordinator oversaw program office activities in conducting the study, coordinated dioxin-related regulatory activities, and served as a central point of contact for the numerous dioxin-related inquiries. Policy guidance was provided by the Dioxin Management Task Force made up of Office Directors from affected programs.

1.2.3 Interagency/International Coordination

A number of federal agencies have been involved in various aspects of the dioxin problem. Many other countries have also had to cope with dioxin incidents.

EPA maintains contact with the Food and Drug Administration (FDA) in interpreting results of fish contamination; with the

National Institute of Occupational Safety and Health (NIOSH) for assessments of worker exposure; and with the Centers for Disease Control (CDC) in Atlanta for human health advisories. EPA is also represented on the Agent Orange Work Group (AOWG), chaired by the Department of Health and Human Services. EPA is the lead agency for U.S. participation in the NATO Committee on the Challenges of Modern Society (CCMS) group established to coordinate international dioxin information exchange activities. EPA is also working closely with the Canadian government in its efforts to investigate municipal waste combustor emissions.

1.3 Background Information on 2,3,7,8-Tetrachlorodibenzo-p-dioxin

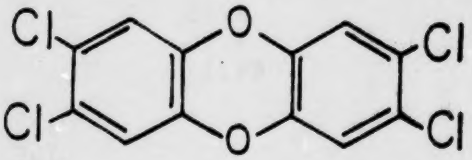
The primary purpose of this report is to present the findings of EPA's investigation of the extent of environmental contamination by 2,3,7,8-TCDD. The following discussion provides general information on the physical, chemical, and toxicological characteristics of 2,3,7,8-TCDD, the dioxin congener of principal concern in the Strategy. Related CDDs and CDFs are also discussed briefly. Additional information is available from a number of sources.

In 1980, EPA's Office of Research and Development published an extensive compilation of information regarding dioxin (EPA, 1980). This report includes information on the chemical reactions which result in formation of 2,3,7,8-TCDD, and on sources and pathways of human exposure.

EPA's Office of Health and Environmental Assessment has completed a Health Assessment Document (HAD) (EPA, 1985a), that compiles and evaluates existing health effects research on 2,3,7,8-TCDD, 1,2,3,7,8-PCDD, and a mixture of two isomers of hexachloro-dibenzo-p-dioxin (HxCDD).

1.3.1 Physicochemical Properties

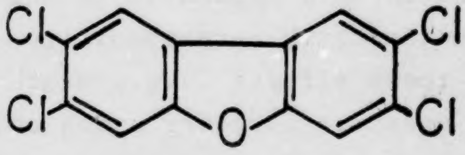
2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) is one of 75 CDD congeners with various chlorine substituents. There are 135 chlorinated dibenzofurans, all of which have the same basic chemical structure and many of which have qualitativity similar toxicities. The chemical structure of 2,3,7,8-TCDD can be depicted as follows:



The dioxin molecular framework consists of two benzene rings connected by two oxygen bridges. There are eight positions where substitution of hydrogen atoms by other atoms or by organic or inorganic radicals can occur.

2,3,7,8-TCDD is an unwanted by-product of the manufacture of several commercial chemicals, particularly the chlorinated phenols. CDDs/CDFs have also been shown to result from certain combustion processes. 2,3,7,8-TCDD is a chemically stable, extremely lipophilic (fat-soluble) molecule with limited solubility in water. In its pure form, 2,3,7,8-TCDD exists as a colorless crystal.

2,3,7,8-TCDF has a similar structure, but has one oxygen bridge rather than two:



2,3,7,8-TCDD

Formula	$C_{12}H_4Cl_4O_2$	
Percent by Wt		
C	44.7	
O	9.95	
H	1.25	
Cl	44.1	
Molecular Wt		322
Melting Point (°C)		305
Decomposition Temp (°C)		>700
Solubility (in Water)		19.3 ppt

Since CDDs are usually formed only in low yields, the minimum conditions leading to formation are poorly defined. Heat, pressure, photostimulation and catalytic action have been shown to encourage the reactions from chlorinated precursors to dioxins. Proper attention to temperature and pH control can minimize formation; however, trace amounts are usually formed along with other impurities (EPA, 1980).

1.3.2 Toxicity

1.3.2a Non-Human

2,3,7,8-TCDD is the most completely studied of the CDDs/CDFs. The compound has demonstrated a variety of toxicities as a result of acute and chronic exposures in animal studies, including death, carcinogenicity, teratogenicity, and immunotoxicity. For some of these effects (e.g., death and reproductive effects) there is great variability among animal species, including sub-human primates. The material is nearly unique in its ability to elicit these effects at very low doses (1-100 ng/kg-day).

2,3,7,8-TCDD has induced hepatocellular carcinomas in two strains of female rats and in both sexes of one mouse strain, thyroid tumors, subcutaneous fibrosarcomas and tumors of the lung, nasal turbinates/hard palate in male rats, and tongue tumors in female rats. These effects occur at extremely low doses. The evidence of carcinogenicity for 2,3,7,8-TCDD in animals is regarded as "sufficient" using the EPA weight-of-evidence classification system for carcinogens (EPA, 1985a).

Other congeners of CDDs/CDFs have not been as well studied as 2,3,7,8-TCDD; however, there is a growing body of literature which indicates that these compounds behave in a qualitatively similar manner, but have widely varying toxicities. Some appear to be nearly as toxic to animals as 2,3,7,8-TCDD while others are much less toxic (see Section 1.3.3, Toxicity Equivalence).

2,3,7,8-TCDD has been shown to be bioavailable to fish from sediment and fly ash. Preferential uptake of CDDs/CDFs substituted in the 2-, 3-, 7- and 8- positions has also been demonstrated (Kuehl et al., 1986). Fish/sediment contamination ratios will vary depending on such factors as species, weight, lipid content, and 2,3,7,8-TCDD sediment concentration.

A significant amount of research has been conducted on the effects of 2,3,7,8-TCDD and other CDDs/CDFs on aquatic organisms. Concentrations as low as 0.056 parts per trillion have been reported to affect coho salmon survival (Miller, 1973). More recent work identified effects on rainbow trout survival at 0.038 ppt (Merhle, 1986).

In lab experiments, concentrations as low as 7.1 ppt combined with exposures of 1-4 days produced significant mortality to fathead minnows while continuous exposure to 1.7 ppt produced 53 percent mortality in 28 days. On the other hand, 2,3,7,8-TCDD had no effects on Daphnia magna at concentrations up to 1,030 ppt during 48-hour exposure followed by 1 week of observation (Adams et al., 1986).

1.3.2b Human

There is much less information available on the effects of exposure of CDDs/CDFs in humans as compared to animals. A number of accidents and/or the use of CDD/CDF-contaminated materials have led investigators to believe that there are cases of significant exposure to CDDs/CDFs. A set of case control studies from

Sweden first raised concern about the possible association of exposure to 2,3,7,8-TCDD and/or phenoxyacetic acid herbicides with a relatively rare form of cancer, known as "soft tissue sarcoma" (STS) (3-5 fold increase) and non-Hodgkins Lymphoma (5 fold increase).

More recent studies in this country (e.g., CDC birth defects study and Ranch Hand morbidity/mortality studies involving Vietnam veterans) and overseas (e.g., New Zealand and Australia) have been unable to detect significant cancer or other adverse health effects in exposed populations. Unfortunately, the cancer studies share the limitations of many epidemiological studies, e.g., low statistical power and limited time since exposure. In addition, examination of individuals clearly exposed as a result of industrial accidents has not revealed consistent, persistent deleterious health effects.

As reported in EPA's Health Assessment Document (EPA, 1985a), the human evidence for the carcinogenicity of 2,3,7,8-TCDD alone is regarded as "inadequate" using the EPA classification criteria, because of the difficulty of attributing the observed effects solely to the presence of 2,3,7,8-TCDD that occurs as an impurity in the phenoxyacetic acids and chlorophenols.

The overall evidence for carcinogenicity, considering both animal and human studies, would place 2,3,7,8-TCDD in the B2 category of EPA's classification scheme. Chemicals in category B2 are regarded as being "probably" carcinogenic in humans.

1.3.3 Fate and Transport

Although significant uncertainties remain, a fair amount of research has been conducted on the fate and transport of 2,3,7,8-TCDD in environmental media.

Physicochemical properties suggest that 2,3,7,8-TCDD will adsorb tightly to organic material in soil, resulting in low mobility. Once in the soil, degradation processes (chemical, biological, etc.) tend to be very slow, with half lives estimated to be 10 years or longer. Freeman and Schroy (1986) suggest that the rate of movement in soil by leaching is insignificant compared to volatilization and erosion.

Thus, except in cases of the presence of mobile, non-polar co-contaminants or where channeling allows particulate transport, large scale movement through the soil is thought to be unlikely. Unfortunately, disposal situations may involve the presence of such mobilizing agents. This may help explain the fact that despite its strong sorptive properties, 2,3,7,8-TCDD has been found distributed vertically through the uppermost soil layers and horizontally beyond the boundaries of the initial contaminated zone (DiDomenico, 1982).

While photolysis (breakdown of contaminants by UV radiation) has been shown to occur, the effect of this mechanism in environmental settings has not been fully determined. The presence of CDDs/CDFs in isolated waterbodies thought to be subject only to influence of airborne particulate transport suggests that CDDs/CDFs are in fact transported in this manner and that rapid photolysis does not occur. Downstream transport of 2,3,7,8-TCDD for considerable distances has also been found at Superfund sites such as Vertac (Jacksonville, Ark.).

Additional information on the fate and transport of 2,3,7,8-TCDD may be found in the Tier 3, 5, 6 and 7 Technical Support Document.

1.3.4 Toxicity Equivalence

While the primary focus of this study was on contamination associated with 2,3,7,8-TCDD, EPA is also concerned with human exposure to other congeners of CDD/CDF.

EPA and others have developed methods for comparing the toxicities of various chlorinated dioxin and furan isomers to that of 2,3,7,8-TCDD. Such Toxicity Equivalence Factor (TEF) approaches express the toxicity of CDD/CDF mixtures in terms of "2,3,7,8-TCDD equivalents". This allows comparison of different toxicities of mixtures for purposes of risk assessment and remedial action planning.

Under ideal conditions, toxicities of mixtures and/or individual constituents are based on long-term whole animal toxicity testing. Unfortunately, complete toxicological information is lacking for most of the congeners of CDDs/CDFs. With the exception of 2,3,7,8-TCDD, the 2,3,7,8-HxCDDs, and 2,3,7,8-TCDF, TEFs are based on estimates of the relative toxicity from *in vitro* tests.

EPA's Science Advisory Board has concluded that there is a plausible basis for the TEF approach of estimating risks associated with CDD/CDF exposures, and has recommended that the Agency adopt this approach on an interim basis, as a matter of science policy. The TEFs will be revised as additional scientific information is developed. EPA's TEFs for the congeners of CDD/CDF considered to be the most toxic are contained in Table 1-1.

More detailed information and a comparison with similar methods developed by the States of California and New York and the governments of Ontario and Switzerland may be found in *Interim Procedures for Estimating Risks Associated with Exposure to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans* (EPA, 1987a).

TABLE 1-1

CDD/CDF ISOMERS OF MOST TOXIC CONCERN[a]

DIOXIN Isomer	TEF[b]	DIBENZOFURAN Isomer	TEF[b]
2,3,7,8-TCDD	1	2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDD	0.5	1,2,3,7,8-PeCDF	0.1
		2,3,4,7,8-PeCDF	0.1
1,2,3,4,7,8-HxCDD	0.04	1,2,3,4,7,8-HxCDF	0.01
1,2,3,7,8,9-HxCDD	0.04	1,2,3,7,8,9-HxCDF	0.01
1,2,3,6,7,8-HxCDD	0.04	1,2,3,6,7,8-HxCDF	0.01
		2,3,4,6,7,8-HxCDF	0.01
1,2,3,4,6,7,8-HpCDD	0.001	1,2,3,4,6,7,8-HpCDF	0.001
		1,2,3,4,7,8,9-HpCDF	0.001

a/ In each homologous group the relative toxicity factor for the isomers not listed is 1/100 of the value listed above.

b/ TEF = toxic equivalence factor = relative toxicity assigned.

1.3.5 Body Burden

Researchers in numerous countries report finding CDDs/CDFs in human adipose tissue. 2,3,7,8-TCDD is often, but not always, found in such investigations. To date, no studies have established a connection between adipose tissue levels and human health effects; nor have researchers definitively established the source(s) of the CDDs/CDFs.

The Centers for Disease Control (CDC) conducted a study of 2,3,7,8-TCDD levels in the adipose tissue of exposed and control persons in Missouri (Paterson et al., 1986). While exposed persons had considerably higher levels of TCDD on average (approximately 80 ppt) than the controls (approximately 7 ppt), all members of both exposed and control groups had detectable levels. Controls ranged from 1.4-20 ppt while exposed ranged from 2.8-750 ppt.

1.3.6 Bioavailability

Researchers have compared the bioavailability (uptake by the biological system) of 2,3,7,8-TCDD from two sites: Times Beach, Missouri and Newark, New Jersey. The Times Beach soil was found to be highly toxic to guinea pigs and produced typical TCDD symptoms. The Newark soil was much less toxic at comparable levels of contamination.

Possible explanations for these apparent differences in bioavailability include differences in soil composition (e.g., amount of organic matter); presence of other compounds that might offset TCDD soil binding; and method of application of the TCDD to the soil (Umbreit et al., 1986).

1.4 Study Design and Implementation

EPA developed a tiered approach to address the first two objectives of the strategy--to study the extent of contamination and to ensure necessary cleanup action at contaminated sites. Seven tiers were developed and ranked by anticipated likelihood of contamination, with a general but not exclusive focus on activities involving 2,4,5-trichlorophenol (2,4,5-TCP).

EPA initially focused on facilities involved with 2,4,5-TCP for a number of reasons.

- 2,3,7,8-TCDD is a known by-product of the manufacture of 2,4,5-TCP.
- 2,4,5-TCP was manufactured in large quantities.
- 2,4,5-TCP is an intermediate in the manufacture of several widely used products including 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) and related herbicides.
- Most of the incidents to date involving high level of 2,3,7,8-TCDD have been associated with 2,4,5-TCP manufacture.

1.4.1 Organization of the Study

EPA defined the following tiers based on decreasing expectation of finding 2,3,7,8-TCDD contamination:

Tier 1 - 2,4,5-Trichlorophenol (2,4,5-TCP) production sites (and associated waste disposal sites)

Tier 2 - Sites (and associated waste disposal sites) where 2,4,5-TCP was used as a precursor in the manufacture of pesticidal products

Tier 3 - Sites (and associated waste disposal sites) where 2,4,5-TCP and its derivative pesticidal products were formulated or packaged into commercial pesticides

Tier 4 - Combustion sources

Tier 5 - Sites where pesticides derived from 2,4,5-TCP have been or are being used on a commercial basis

Tier 6 - Certain organic chemical and pesticide manufacturing facilities where improper quality control on certain production processes could have resulted in the inadvertent formation of 2,3,7,8-TCDD

Tier 7 - Networks of existing ambient stations where fish and soil were sampled to determine whether 2,3,7,8-TCDD was widespread in the environment and, if so, at what levels

The tier 1 and tier 2 facilities, and their associated waste disposal sites, tiers "1A and 2A" respectively, were the sites where EPA expected to find the most contamination. They were investigated through the Superfund program because of its authority to address contaminated sites. Remedial actions at the sites in these tiers will continue in the future.

Tiers 3, 5, 6 and 7 were managed by the Office of Water Regulations and Standards (OWRS). The tier 4 work was managed by the Office of Air Quality Planning and Standards (OAQPS).

Detailed project plans were prepared for tiers 3 through 7. The project plans underwent extensive internal and external review. External reviewers included staff of the Centers for Disease Control and the Office of Technology Assessment, several members of EPA's Science Advisory Board, and the American Chemical Society.

In addition to conducting basic research, EPA's Office of Research and Development (ORD) provided extensive technical and analytical support to the project.

Regulatory activities were undertaken by the specific Offices in EPA with the appropriate legislative authority and media expertise. (See Chapter 5.)

1.4.2 Detection Limits/Analytical Support

During the initial round of investigations in Missouri, EPA requested assistance from CDC in interpreting the significance of 2,3,7,8-TCDD contamination at a residential site. CDC developed a health advisory level of 1 part per billion (ppb) for residential soil (Kimbrough et al., 1984). A major consideration in arriving at this level was the presence of small children, who typically play in and ingest residential soil. CDC suggested that a somewhat higher level might be acceptable in non-residential settings where continuous exposure of children would not occur, but cautioned that lower levels might be of concern on pastures and rangelands where there is potential bioaccumulation in the food chain.

Although 1 ppb was intended to be site-specific, the characteristics at residential sites tend to be similar. This guidance provided important design parameters for the study.

For tiers 1 and 2, EPA selected a detection limit of 1 part per billion (1 ppb) based on the generally non-residential nature of the production and disposal facilities. Similar reasoning resulted in the selection of a detection limit of 1 ppb for soil sampling at sites in tiers 3 and 6.

The investigations in tiers 5 and 7 (fish and soil) were in the nature of a "background" evaluation, thus the objective was to employ state-of-the-art detection capability to determine whether 2,3,7,8-TCDD was present in the sample. A nominal detection limit of 1 part per trillion (ppt) was selected for fish and soil samples, using high resolution gas chromatography/high resolution mass spectrometry. This technology allows a detection limit in the parts per quadrillion (ppq) range in water samples although the method is much more experimental when applied to these samples.

The 1 ppt detection limit and the number of samples to be processed resulted in pressing the state-of-the-art in both capability and capacity. To meet this need and to provide requisite consistency for a nationwide study of this nature, EPA established a consortium of three in-house laboratories--the so-called "Troika".

Because of the low levels expected in combustion source emissions, the Troika also performed ppt analyses for the tier 4 samples. Analysis of tier 4 samples addressed additional CDD/CDF congeners because 2,3,7,8-TCDD generally represents only a small part of the total CDDs/CDFs generated by these facilities.

As used in this report, the term "detection limit" is synonymous with "analytical method quantitation limit," that is, the contaminant concentration required to produce a signal with peak height 2.5 times the background signal level.

Chapter Two

TIERS 1 AND 2

This chapter presents EPA's investigatory and cleanup efforts for sites in tiers 1 and 2.

- Tier 1 - 2,4,5-trichlorophenol (2,4,5-TCP) production sites and associated waste disposal sites
- Tier 2 - Sites where 2,4,5-TCP was used as a precursor to make pesticidal products, and associated disposal sites*/

The objective in these tiers was to identify contaminated sites and develop appropriate response measures. EPA estimated that most 2,3,7,8-TCDD produced in this country would be associated with tier 1 and 2 sites.

Activities at these sites were assigned to the Office of Solid Waste and Emergency Response (OSWER). OSWER is also responsible for sites from the other five tiers where significant 2,3,7,8-TCDD contamination is discovered. Funding and authority for these investigations and response actions comes from the Superfund program.

EPA had been addressing 2,3,7,8-TCDD sites prior to the National Dioxin Strategy. This report does not generally distinguish ongoing activities from those conducted after the Strategy was established. Additional information on tiers 1 and 2 is contained in the Technical Support Document (EPA, 1987c).

2.1 Approach

Investigation and cleanup at tier 1 and 2 sites are modeled after the approach taken under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program (Superfund). The major difference is that, for the first time, the Agency has targeted industry-specific production and disposal facilities.

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*/ Waste disposal sites associated with Tiers 1 and 2 are referred to as Tiers 1a and 2a sites, respectively.

EPA conducted extensive data base research and used enforceable information request letters to identify production facilities and associated waste disposal sites. As needed, additional data were collected from site visits and employee interviews.

Field testing was conducted to determine actual 2,3,7,8-TCDD contamination. EPA employed a targeted approach, sampling in locations most likely to be contaminated (i.e., loading areas, storage areas, production areas). If off-site migration was suspected, samples were collected outside the facility boundary.

Sampling plans were developed in consultation with the Centers for Disease Control (CDC) to ensure that if 2,3,7,8-TCDD was detected, the data would be usable by CDC in developing health recommendations. Quality assurance/quality control protocols that follow Superfund procedures were developed to ensure that all data generated would be of known quality.

If 2,3,7,8-TCDD contamination was detected, a site-specific decision on the need for an immediate or longer term response action was made in consultation with CDC. Where possible, potentially responsible parties (PRPs) were encouraged to take appropriate response action.*/ If necessary, response activities were performed under Superfund.

All activities have been coordinated with State and local authorities as well as other Federal agencies such as the Centers for Disease Control (CDC), the National Institute for Occupational Safety and Health (NIOSH), the Food and Drug Administration (FDA) and the Federal Emergency Management Agency (FEMA).

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*/ A potentially responsible party is any person who: 1) owned, operated or otherwise controlled activities at any facility where hazardous substances were disposed of; 2) arranged for disposal or treatment of a hazardous substance; or 3) accepted a hazardous substance for transport to disposal or treatment facilities.

2.2 Findings

2.2.1 Universe of Tiers 1 and 2

There are 100 sites in tiers 1 and 2. Table 2-1 shows a breakdown of sites by tier.

TABLE 2-1

OSWER DIOXIN SITES BY TIER

Tier	1	1a	2	2a
No. of Sites:	11	53	10	26

It was originally thought that there were about 450 tier 1 and 2 sites (50 production sites and about 400 associated disposal sites). The difference in the actual versus the estimated number of tier 1 and 2 facilities has two bases. First, many of the facilities alleged to have produced the chemicals of concern, in fact, did not. For example, they may have been registered with EPA to produce 2,4,5-TCP and some of its derivatives, but only formulated selected derivatives in actuality. This would make them a tier 3 rather than a tier 1 or 2 facility. Second, those facilities that did produce 2,4,5-TCP or use it as a precursor had an average of 4 associated disposal sites, instead of the originally estimated 8 to 10.

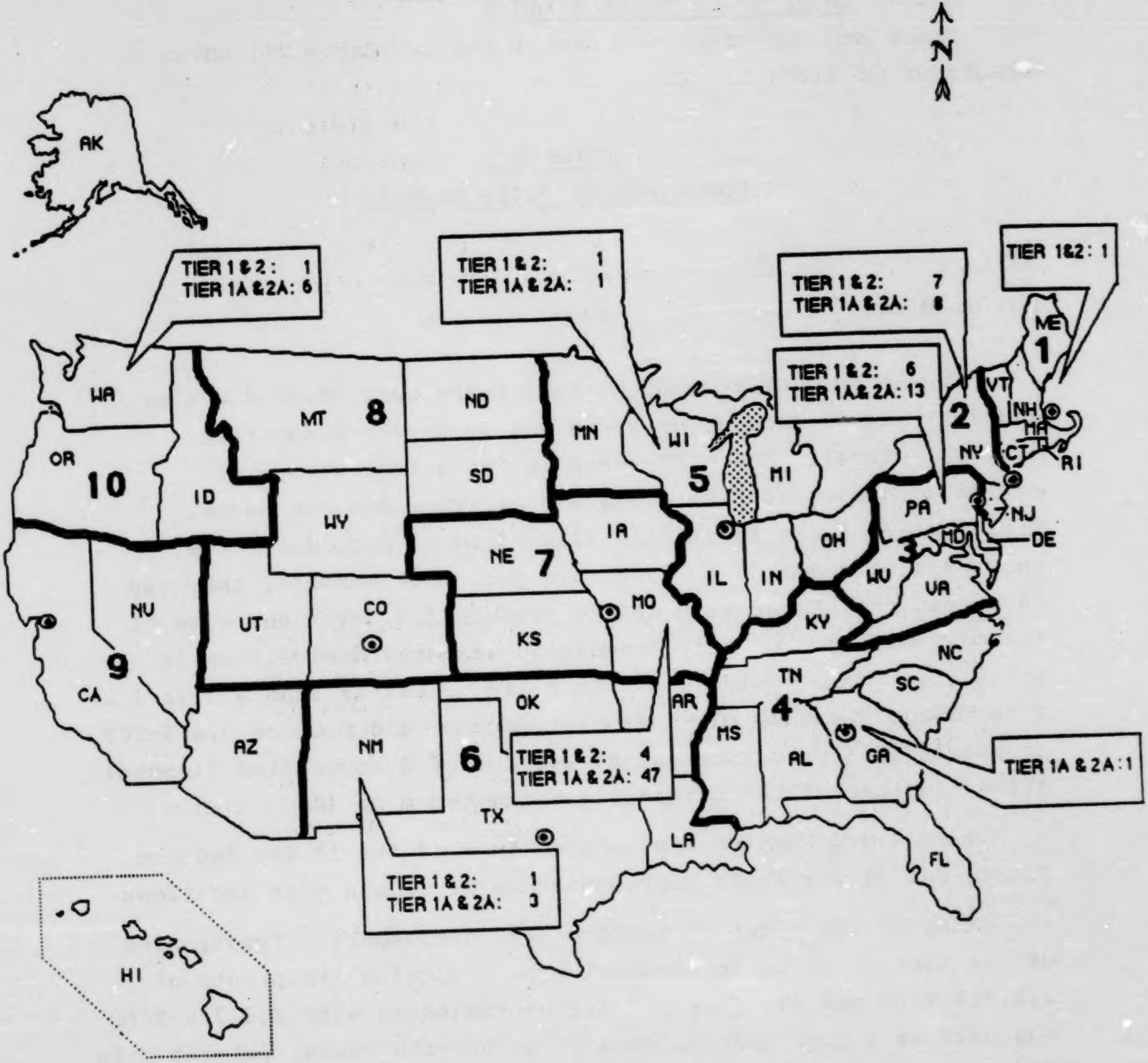
Tier 1 and 2 sites are located in 8 of the 10 EPA Regions. Figure 2-1 is a graphic representation of dioxin site locations.

Many of the sites of concern are in Missouri. Twenty-nine of the tier 1A sites in Missouri were unwitting recipients of 2,3,7,8-TCDD waste. Recycled oil contaminated with 2,3,7,8-TCDD was used as a dust control measure on private roads, parking lots and horse arenas. Later, contaminated soils from a horse arena were used as fill dirt at several farms and residences.

Prior to the National Dioxin Strategy, EPA had sampled the majority of the 200 sites in Missouri alleged to have been sprayed with contaminated waste oil. No 2,3,7,8-TCDD was

FIGURE 2-1

OSWER DIOXIN SITES REGIONAL DISTRIBUTION


N
AK
TIER 1 & 2: 1
TIER 1A & 2A: 6
TIER 1 & 2: 1
TIER 1A & 2A: 1
TIER 1 & 2: 7
TIER 1A & 2A: 8
TIER 1&2: 1
TIER 1 & 2: 6
TIER 1A& 2A: 13
WA
OR
10
ID
MT
8
ND
SD
WY
MN
WI
5
MI
NY
2
VT
NH
ME
1
MA
CT
RI
NJ
PA
DE
MD
3
OH
WV
VA
IA
NE
7
IL
IN
KY
NV
UT
CO
KS
MO
9
CA
AZ
NM
6
OK
TX
AR
TN
4
NC
SC
MS
AL
GA
LA
FL
TIER 1 & 2: 4
TIER 1A & 2A: 47
TIER 1A & 2A: 1
TIER 1 & 2: 1
TIER 1A & 2A: 3
HI

◎ EPA REGIONAL OFFICE

TOTALS

TIER 1 & 2: 21
TIER 1A & 2A: 79

detected at the 1 ppb detection limit at 110 of the sites. EPA determined that other sites had never been sprayed.

It is of particular note when considering the extent of environmental contamination, that no other situations such as in Missouri have been discovered. That is, the widespread distribution of contaminated material at numerous locations occurred only in Missouri.

Twenty* dioxin sites are on or proposed for the Superfund National Priorities List (NPL). The NPL identifies the targets for long-term action under Superfund. Most of these NPL sites, such as Love Canal in Niagara Fails, New York, are on the NPL for chemical contamination problems beyond dioxin. The 20 sites on the NPL or proposed NPL are:

Baird and McGuire	Holbrook, MA
Bliss Property	Ellisville, MO
Conservation Chemical	Kansas City, MO (proposed)
Diamond Alkali	Newark, NJ
Drake Chemical	Lock Haven, PA
Fike Chemicals	Nitro, WV
Hooker Chemical (Hyde Park)	Niagara Falls, NY
Hooker Chemical (Love Canal)	Niagara Falls, NY
Hooker Chemical (S-Area)	Niagara Falls, NY
Hooker Chemical (102nd St.)	Niagara Falls, NY
Minker/Stout/Romaine Creek	Imperial, MO
Moyers Landfill	Collegeville, PA
NIES	Furley, KS (proposed)
Quail Run	Gray Summit, MO (proposed)
Rohm & Haas	Bristol, PA (proposed)
Shenandoah Stables	Moscow Mills, MO
Syntex	Verona, MO
Times Beach	Times Beach, MO
Vertac	Jacksonville, AR
Western Processing	Kent, WA

2.2.2 Other Dioxin-Contaminated Sites

Under the Dioxin Strategy, sites found to be contaminated in tiers 3 through 7 are referred to OSWER for possible CERCLA action. To date, 13 sites have been referred from tiers 3 through 7. These are described in greater detail in the next chapter.

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* In one case, five residential areas in Missouri are listed as one NPL site (Minker/Stout/Romaine Creek/Sullins/Cashel). The site is known as Minker/Stout/Romaine Creek.

Although 2,3,7,8-TCDD has generally not been found in commercial grade pentachlorophenol (PCP), 2,3,7,8-TCDD has been detected at a number of PCP wood treatment facilities. At an inactive facility in Butte, Montana, for example, 2,3,7,8-TCDD was detected at a level of 28 parts per billion (ppb). These sites are being handled by EPA's Superfund program.

EPA's Office of Solid Waste (OSW) is investigating wastes from PCP wood treatment for possible designation as hazardous under RCRA. OSW is collecting information on 2,3,7,8-TCDD and other environmental contamination associated with wood treatment operations.

EPA is also monitoring or responding to other sites, such as sites where PCBs were burned.

2.2.3 Extent of Contamination of Tier 1 and 2 Facilities

EPA, States, or responsible parties have sampled all of the 21 production sites in tiers 1 and 2 and most of the 79 tier 1A and 2A disposal sites for 2,3,7,8-TCDD. EPA's definition of disposal sites goes beyond traditional active or inactive disposal facilities to include sites such as those in Missouri where contaminated material was dumped or received unknowingly.

Eleven tier 1 and 2 production and disposal sites are classified as requiring "no further action" under the Strategy. This classification is based on sampling results that indicate very low (i.e., 0.7 ppb) or undetectable levels of 2,3,7,8-TCDD, using analytical methodology capable of detecting levels of 1 ppb. These sites are:

Calgon Corporation	Pasadena, TX
Drake Chemical	Lock Haven, PA
Eastman Kodak	Rochester, NY
Georges Creek	Poca, WV
GROWS	Morrisville, PA
Millmaster Onyx	Berkeley Heights, NJ
Moyers Landfill	Collegeville, PA
Resource Recovery	Pasco, WA
Rhone Poulenc	Portland, OR

Sourth Charleston Landfill	South Charleston, WV
Union Carbide	South Charleston, WV

Two of these sites (Drake Chemical and Moyers Landfill) are on the Superfund NPL for contamination problems unrelated to dioxin.

Where 2,3,7,8-TCDD was detected, levels were generally highest in the vicinity of actual waste handling operations (processing, loading, storage). At sites where concentrated 2,4,5-TCP production wastes were stored or disposed of, 2,3,7,8-TCDD concentrations were as high as 2,000 parts per million (2,000 ppm). At most sites, however, 2,3,7,8-TCDD levels in soils were in the parts per billion (ppb) range. In fish samples from nearby lakes and streams, 2,3,7,8-TCDD was measured in terms of parts per trillion (ppt). A summary of sampling data from each site is provided in Table 2-2.

The majority of 2,3,7,8-TCDD contamination at tier 1, 1A, 2 and 2A sites remained on-site. However, fish contamination and off-site soil migration were detected in a number of instances.

2.2.3a Fish Advisories

Fish advisories have been issued by State health agencies for nine sites. The Michigan Department of Public Health issued a fish advisory for certain species (catfish and carp) in the Tittabawassee River downstream from Dow Chemical in Midland, due to dioxin contamination. The remaining advisories generally recommend consuming fish from specified areas no more than once or twice per month. Six sites are located on or near the Niagara River:

- Hooker Chemical (Buffalo Ave.)
- Hooker Chemical (S-area)
- Hooker Chemical (Love Canal)
- Hooker Chemical (102nd St.)
- Hooker Chemical (Hyde Park).
- Olin Chemical Corp.

An advisory was issued by the New York Department of Environmental Conservation concerning fish obtained from the entire Niagara River during 1985 and 1986. Similarly, an advisory was issued by the State of Arkansas for fish from the Bayou Meto from

Jacksonville, Arkansas (near Vertac), to the Arkansas River; this advisory has been issued for an indefinite period. Fish from the Spring River from Verona, Missouri (Syntex), to the Oklahoma line should be consumed with caution until further notice as well. An advisory (not associated with a specific site) was issued by the Governor of West Virginia for the Kanawha River between the Coal River at St. Albans and the Ohio River.

2.2.3b Off-site Contamination

Off-site 2,3,7,8-TCDD soil contamination at levels of concern has been confirmed in seven cases:

Diamond Shamrock	Newark, NJ
Brady Metals	Newark, NJ
Dow Chemical 1/	Midland, MI
Love Canal	Niagara Falls, NY
Hyde Park	Niagara Falls, NY
Vertac	Jacksonville, AR
Bliss Tank Property (1A)	Frontenac, MO

To illustrate the type of environmental problems EPA can face at tier 1 or 2 facilities, several of the facilities with off-site contamination are briefly discussed below.

Diamond Alkali - Newark, New Jersey

This facility was a former herbicide manufacturing site involved in the production of Herbicide Orange. 2,4,5-TCP was manufactured at the plant from February 1946 through August 1969. The facility is located along the Passaic River in an industrial/commercial section of Newark which contains a sizable number of residential dwellings. The site is on the Superfund NPL.

Sampling Data -- On-site soil samples confirmed high (60 to 1200 ppb) levels of 2,3,7,8-TCDD. Later analyses showed one sample to be greater than 50 ppm.

An extensive off-site testing program in the neighborhood covered a 4,000 ft radius and consisted of four phases: areas of

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1/ The contaminated off-site area is now included within the plant fence line.

human habitability (including an 800-family public housing unit, a church and a school): open spaces (parking lots, street corners); transport routes (roads, rail line and storm sewers) and the Passaic River (sediments and fish). 2,3,7,8-TCDD was detected above 1 ppb in samples taken at the following locations:

- Passaic River (bottom sediments): 5 of 35 samples greater than 1 ppb (range 1.2 to 3.0 ppb)
- Public Contact Areas (soil/sweep):
  - Hayes Park East--2 of 11 samples (1.0-3.1 ppb)
  - Joseph Street --3 of 5 samples (1.1-4.1 ppb)
- Habitability Sampling
  - Esther Street --1.1 ppb (vacuum bag)
  - SCA --1.2 ppb (air conditioner filters)
  - Joseph Street --5.8 ppb (soil)
- Transportation Routes (soil/sweep)
  - Esther Street --4 samples 1.0-5.9 ppb
  - Lockwood Street--9 samples 1.5-7.3 ppb
  - Euclid Street --3 samples 1.8-4.2 ppb
  - Railroad --27 samples 1.1-520 ppb

Activities Undertaken to Date -- As partial site stabilization, a tarp was installed over on-site areas of contamination and a fence was installed in the back of the property. Adjacent residential areas have been vacuumed and swept to remove 2,3,7,8-TCDD contamination.

Diamond Shamrock is now performing a feasibility study that will be used by EPA and the State of New Jersey to determine appropriate cleanup actions.

Brady Metals - Newark, New Jersey

Brady Metals is a scrap metal facility that allegedly received contaminated reactor vessels from the Diamond Shamrock facility. The site is located in a residential/industrial area known as the Iron-bound section of Newark, New Jersey. Contamination resulted from disassembly of reactor vessels on-site. Dioxin contamination has also been detected off-site. It is believed to have been transported by wind, erosion and vehicles.

Sampling Data -- Dioxin concentrations above 5 ppb were found over most portions of the site with many samples from the western half of the site exceeding 100 ppb. The highest concentration was 3,500 ppb.

Off-site data were summarized above in the discussion of Diamond Shamrock.

Activities Undertaken to Date -- An impermeable barrier, filters, and fence screening were installed to prevent off-site migration and to control dust. Nearby streets were cleaned, soil was excavated from the nearby road and stored on-site. New Jersey provided security to prevent public exposure. The responsible party has assumed cleanup responsibility. The State is providing compliance monitoring at the site.

Hooker Specialty Chemicals Division - Niagara Falls, New York

The Hooker Niagara Falls facility was involved in the manufacture of 2,4,5-TCP from 1949-1972. The facility is located along the Niagara River in a highly industrialized setting. Soluble 2,4,5-TCP wastes were sewered and discharged into the Niagara River. The Province of Ontario, Canada is located across the Niagara River, a distance of approximately 2 miles. On-site landfilling of 2,4,5-TCP residues took place at the S-Area disposal location which lies 10 yards west of the City of Niagara Falls Water Treatment Plant. Existing data indicate that contamination from the S-Area disposal site has infiltrated the main intake tunnel of the water treatment plant. The S-Area site is on the Superfund National Priorities List (NPL).

Sampling Data -- Hot spots were found at the former 2,4,5-TCP production area with one particularly high hit at what is thought to be the former TCP waste staging area. On-site sediment samples collected from catch basins ranged from 4.6-524 ppb. On-site subsurface soil samples ranged from ND to 18.6 parts per million. Off-site sampling found 8.6 ppb in one sewer sediment sample and 1.1 ppb in a surface soil sample.

Activities Undertaken to Date -- EPA and New York State are negotiating with Hooker to determine if the company will undertake necessary feasibility studies and remedial investigations at its production facility.

Love Canal - Niagara Falls, New York

More than 21,000 tons of chemicals were disposed of in Love Canal. In 1954, 3,000 cubic yards of fly ash and BHC cake taken from Love Canal were used as fill at the nearby 93rd Street School. The Love Canal site consists of a large former residential area (the so-called Emergency Declaration Area (EDA)) surrounding the Love Canal area proper, some of whose residents have chosen to remain in the area. The site was used as a disposal site from approximately 1942-1952.

Sampling Data -- Several sampling programs for 2,3,7,8-TCDD have been conducted, including the 1980 EPA monitoring at Love Canal; 1983 Malcolm Pirnie sampling; 1984 NYSDOH sampling; and 1983 EC Jordan Borehole Investigation. Results included:

Medium (soil, water, etc.)	Location (on- or off-site)	High Concentration (ppb)
Sediments:		
Bergholtz Creek	Off-site (EDA area)	45.8
Black Creek	Off-site (EDA area)	4.0
102nd St. Outfall	Off-site	3.3
Sewer	Off-site (EDA area)	650
Soil:		
93 St. School (3+ ft. deep)	Off-site (EDA area)	1.6
Canal-surface	On-site (on Canal proper)	6.7

Actions Undertaken to Date -- A cap, including a synthetic liner, now covers the canal proper. A leachate collection system and leachate treatment plant are operating. Sewers exiting the canal were severed and plugged. It is expected that contaminants are no longer migrating from the canal due to these measures.

Significant additional cleanup and long-term monitoring activity is anticipated at this site.

Dow Chemical Company - Midland, Michigan

Dow Chemical Company U.S.A. - Michigan Division (Dow) is a chemical manufacturing plant which produced 2,4,5-TCP. The 2,4,5-TCP and its derivatives were formulated into pesticide products. Dow historically landfilled its wastes on-site. Dow is also a combustion source because of its on-site incinerator.

Dow began brine production operations in 1897. Commercial production of a variety of chlorinated phenols began in the mid-1930's and ended in the late 1970's.

Dow is located within Midland, Michigan (population approximately 37,250), and the manufacturing complex encompasses a land area of approximately 1,500 acres.

Sampling Data -- Dow and the surrounding area have been extensively sampled for dioxin by Dow and the U.S. EPA. In December 1983, initial sampling detected 2,3,7,8-TCDD at levels up to 52 parts per billion (ppb) in soil on the plant site and up to 2 ppb at the plant perimeter (now on-site). 2,3,7,8-TCDD has been detected in fish in the Tittabawasee River at levels from 12 to 530 parts per trillion (ppt). 2,3,7,8-TCDD soil samples in residential areas were less than 1 ppb. 2,3,7,8-TCDD is also being monitored in the ambient air and in the emissions from Dow's incinerator. In 1985, Dow performed follow-up soil sampling and reported a cone of contaminated soil with concentrations ranging from non-detectable outside the cone (Det. Limit .005 ppb) up to 1500 ppb. The contamination is from historical releases from a tank farm associated with the production of chlorophenol. The highest concentration was detected in the center of the cone at a depth of 10-12 feet.

Activities Undertaken to Date -- In 1984 and 1985, under the terms of a U.S. EPA Administrative Order, Dow removed contaminated demolition debris and capped contaminated areas to prevent airborne migration and direct contact with contaminants. The State of Michigan has issued a fishing advisory for the Tittabawassee River downstream of the Dow plant. An NPDES limit of 10 ppq (parts per quadrillion) 2,3,7,8-TCDD in Dow wastewater discharge into the Tittabawassee River was also established as an interim effluent limitation.

Pursuant to the Hazardous and Solid Waste Amendments (HSWA) to RCRA of 1984, Dow is required to address corrective action for all releases of hazardous waste or constituents from any solid waste management unit. This will encompass both on-site and off-site releases of dioxin, including highly contaminated areas. Dow's compliance plan for corrective action is currently under review. EPA is currently writing a Corrective Action Plan (CAP). Interim corrective measures are expected to be approved before the end of September 1987. Further investigations and corrective measures will be incorporated into Dow's HSWA permit.

Vertac - Jacksonville, Arkansas

The site is located adjacent to a residential area of Jacksonville, Arkansas, just north of Little Rock. In the mid-fifties, Reasor-Hill Company began the manufacture of phenoxy herbicides at the site, including the manufacture of 2,4,5-T. In 1961, the plant was sold to Hercules, who operated until 1972 and produced 2,4-D, 2,4,5-T, 2,4,5-TP and Herbicide Orange. In 1971, Vertac, Inc. began operation at the site. From the time production began during the Reasor-Hill era until March 1979, one of the major products produced was 2,4,5-T.

Solid and liquid waste from the Reasor-Hill period up to 1974 were buried on-site in a series of landfills. All surface flow from Vertac ends up in Rocky Branch Creek which runs along the western edge of the plant. Non-contact cooling water from the Reasor-Hill operations was held in a dammed portion of Rocky Branch. Rocky Branch drains into Bayou Meto about 2 miles south of the Vertac plant.

Sampling Data -- 2,3,7,8-TCDD has been detected both on- and off-site:

Highest levels found were:

° Equalization basin on site	1,200 ppb
° Sewer collection line south of facility	10.9 ppb
° Oxidation ponds from City of Jacksonville sewage treatment facility	3.4 ppb
° Sewerline	334 ppb
° Fish	798 ppt

Activities Undertaken to Date -- Pursuant to a consent decree, Vertac/Hercules are containing wastes on-site with slurry walls, French drains, and clay caps. Some sediments and contaminated soils are being contained in a clay vault on-site. EPA did not feel this remedy provided sufficient protection to human health and the environment; however, Vertac's remedy was found to be judicially acceptable. EPA will closely monitor this site.

An off-site Remedial Investigation/Feasibility Study (RI/FS) is in progress. 2,3,7,8-TCDD has been found in fish as far as roughly 100 miles downstream from the plant. The Arkansas Department of Health has quarantined Rocky Branch from where it flows through the Vertac property, to its confluence with Bayou Meto and has quarantined Bayou Meto from Jacksonville to the Bayou's confluence with the Arkansas River.

2.3 Response Actions

Initial Agency actions responding to verified contamination have focused on mitigating the threat of public exposure. Inhalation, soil ingestion, dermal contact, and fish consumption are the major exposure routes of concern. Cleanup actions, emergency removals and associated health and fish consumption advisories have focused on reducing potential exposure via these routes. EPA prioritizes its cleanup actions according to the risks associated with each site.

Cleanup action has been taken at 11 of the 21 production sites in tiers 1 and 2. Some of these sites have been the recipients of multiple actions; many will receive additional cleanup.

Cleanup activities include:

- Removal Actions--designed to mitigate, in a relatively short time-frame, a threat or potential threat to humans and the environment; removals include such activities as:
  - Relocation of threatened populations
  - Restricting access by fence construction or sign posting
  - Excavation of contaminated soils with on- or off-site storage
  - Capping or paving measures to control migration
  - Cleaning/vacuuming of contaminated surfaces
- Remedial Actions--to mitigate, in a longer time-frame and consistent with a permanent remedy, a threat or potential threat to human health and the environment; remedial actions may encompass the same type of activities as removals.

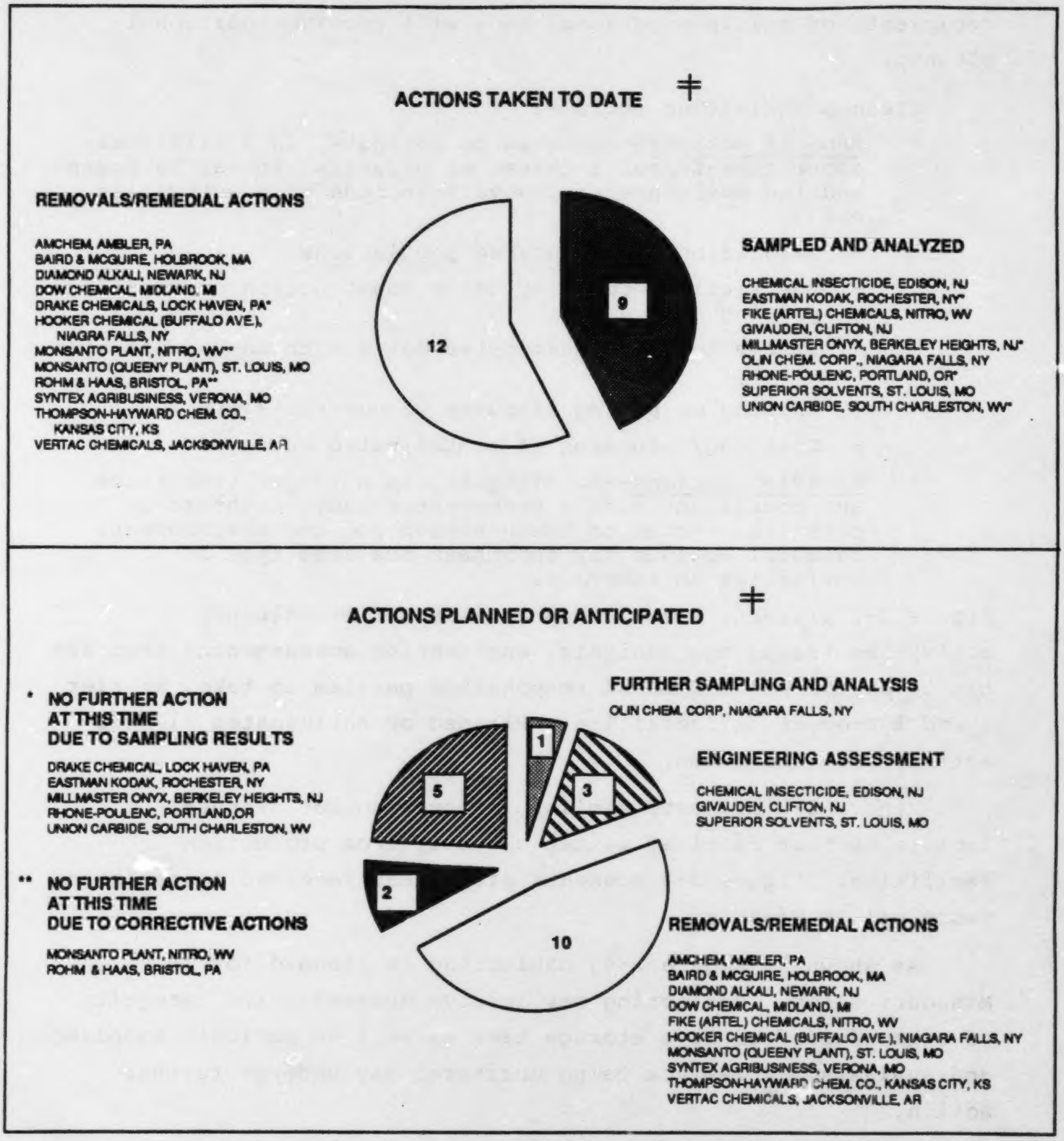
Figure 2-2 presents the cleanup actions and pre-cleanup activities (sampling, analysis, engineering assessments) that EPA has taken, or has compelled responsible parties to take, at tier 1 and 2 production facilities. Planned or anticipated cleanup actions are also given.

Figure 2-3 presents similar information for disposal facilities that received wastes directly from production facilities. Figure 2-4 presents sites that received contaminated waste oil in Missouri.

As shown in Figure 2-4, monitoring is planned for 16 Missouri sites. Monitoring may involve observing the integrity of a paved surface or a storage tank as well as periodic sampling and analysis. Sites now being monitored may undergo further action.

FIGURE 2-2

PRODUCTION FACILITIES
TIERS 1 AND 2



ǂ IF A SITE UNDERWENT (OR IS ANTICIPATED TO UNDERGO) MORE THAN ONE ACTIVITY, THE MOST ADVANCED ACTIVITY IS INDICATED. SOME ACTIVITIES ARE ONGOING.

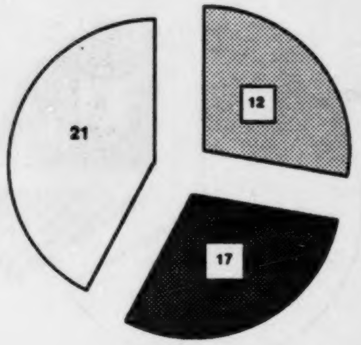
FIGURE 2-3

DISPOSAL SITES - TIERS 1A AND 2A WASTES RECEIVED DIRECTLY FROM PRODUCTION FACILITY

ACTIONS TAKEN TO DATE ‡

REMOVALS/ REMEDIAL ACTIONS

BALDWIN PARK, AURORA, MO
BILL RAY FARM, BARRY CO., MO*
BLISS TANK PROPERTY, FRONTENAC, MO
BRADY METALS, NEWARK, NJ
DENNY FARM SITE, BARRY CO., MO
S. B. ERWIN FARM, LAWRENCE CO., MO*
HOOKER CHEM. (LOVE CANAL), NIAGARA FALLS, NY
HOOKER CHEM. (HYDE PARK), NIAGARA FALLS, NY
HOOKER CHEM (S-AREA), NIAGARA FALLS, NY
HOOKER CHEM. (102nd St.), NIAGARA FALLS, NY
MANILA CREEK, POCA, WV
MONSANTO LANDFILL, NITRO, WV*
NEOSHO DIGESTER, NEOSHO, MO
NEOSHO TANK SPILL AREA, NEOSHO, MO*
NIES (1A), FURLEY, KS
NIES (2A), FURLEY, KS
NITRO DUMP, NITRO, WV*
ROBERT RUSHA FARM, BARRY CO., MO*
ROYAL TALLEY FARM, MCKINLEY, MO*
SYNTEX LAGOON, SPRINGFIELD, MO
WESTERN PROCESSING CO., KENT, WA*



PRELIMINARY INVESTIGATION

BFI, LIVINGSTON, LA*
BFI (1A), MISSOURI CITY, MO*
BFI (2A), MISSOURI CITY, MO*
BOYERTOWN SCRAP, BOYERTOWN, PA*
CHEM CLEAR, CHESTER, PA*
CHEM. WASTE MNGMT., INC., EMELLE, AL*
CHEM. WASTE MNGMT., INC., PORT ARTHUR, TX*
CHEMTROL/SCA SERVICES, MODEL CITY, NY
COLWELL LANE, PA*
TOSCANO TRUCKING*
WASHINGTON IRON & METAL, PHILADELPHIA, PA*
WHEELING DISPOSAL, AMAZONIA, MO

SAMPLED AND ANALYZED

ALKALI LAKE, SOUTHEASTERN, OR
CALGON CORP., PASADENA, TX*
CHEM. SECURITY SYSTEMS, INC., ARLINGTON, OR
CONSERVATION CHEMICAL CO., KANSAS CITY, MO
ENVIRO. SERV. OF IDAHO, INC., GRANDVIEW, ID*
GEORGES CREEK, POCA, WV*
GREEN VILLAGE DISPOSAL, GREEN VILLAGE, NJ*
GROWS., MORRISVILLE, PA*
HEIZER CREEK, POCA, WV
MOYERS LANDFILL, COLLEGEVILLE, PA*
POCA LANDFILL, POCA, WV
POSEYVILLE LANDFILL, POSEYVILLE, MI
RESOURCE RECOVERY, PASCO, WA*
SOUTH CHARLESTON LANDFILL, S. CHARLESTON, WV*
SPRING RIVER, VERONA, MO
ST. JOHNS LANDFILL, PORTLAND, OR
SYNTEX AGRIBUSINESS, VERONA, MO

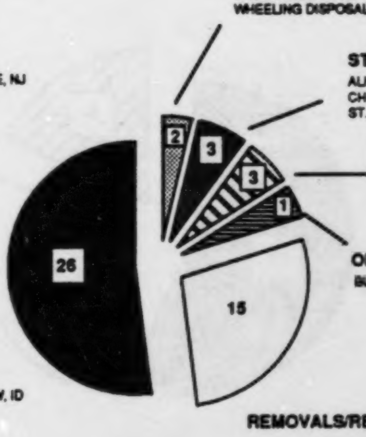
ACTIONS PLANNED OR ANTICIPATED ‡

NO FURTHER ACTION AT THIS TIME

DUE TO SAMPLING RESULTS	CALGON CORP., PASADENA, TX GEORGES CREEK,POCA, WV GREEN VILLAGE DISPOSAL, GREEN VILLAGE, NJ GROWS, MORRISVILLE, PA MOYERS LANDFILL, COLLEGEVILLE, PA RESOURCE RECOVERY,PASCO, WA SOUTH CHARLESTON LANDFILL, WV
DUE TO CORRECTIVE ACTIONS	BILL RAY FARM, BARRY CO., MO S. B. ERWIN FARM, LAWRENCE CO., MO MONSANTO LANDFILL, NITRO, WV NEOSHO TANK SPILL AREA, NEOSHO, MO NITRO DUMP, NITRO, WV ROBERT RUSHA FARM, BARRY CO., MO ROYAL TALLEY FARM, LAWRENCE CO., MO WESTERN PROCESSING, KENT, WA
REFERRED TO RCRA PROGRAM	BFI (1A), MISSOURI CITY, MO BFI (2A), MISSOURI CITY, MO BFI, LIVINGSTON, LA CHEM. WASTE MNGMT., EMELLE, AL CHEM. WASTE MNGMT., PORT ARTHUR, TX ENVIRO. SERV. OF IDAHO, INC., GRANDVIEW, ID
UNABLE TO TRACE WASTE	BOYERTOWN SCRAP, BOYERTOWN, PA CHEM CLEAR, CHESTER, PA COLWELL LANE, PA WASHINGTON IRON & METAL, PHILA, PA
UNABLE TO IDENTIFY DISPOSAL SITES	TOSCANO TRUCIGNG

SAMPLING AND ANALYSIS

CHEMTROL/SCA SERVICES, MODEL CITY, NY
WHEELING DISPOSAL, AMAZONIA, MO



STATE MONITORING

ALKALI LAKE, SOUTHEASTERN, OR
CHEM. SECURITY SYSTEMS, INC., ARLINGTON,OR
ST. JOHNS LANDFILL, PORTLAND, OR

ENGINEERING ASSESSMENT

HEIZER CREEK, POCA, WV
HOOKER CHEM. (102nd St.), NIAGARA FALLS, NY
POCA LANDFILL, POCA, WV

ONGOING NEGOTIATION/LITIGATIONS

BLISS TANK PROPERTY, FRONTENAC, MO

REMOVALS/REMEDIAL ACTIONS

BALDWIN PARK, AURORA, MO
BRADY METALS, NEWARK, NJ
CONSERVATION CHEMICAL, KANSAS CITY, MO
DENNY FARM SITE, BARRY CO., MO
HOOKER CHEM. (HYDE PARK), NIAGARA FALLS, NY
HOOKER CHEM. (LOVE CANAL), NIAGARA FALLS, NY
HOOKER CHEM. (S-AREA), NIAGARA FALLS, NY
MANILA CREEK, POCA, WV

NEOSHO DIGESTER, NEOSHO, MO
NIES (1A), FURLEY, KS
NIES (2A), FURLEY, KS
POSEYVILLE LANDFILL, POSEYVILLE, MI
SPRING RIVER, LAWRENCE CO., MO
SYNTEX AGRIBUSINESS, VERONA, MO
SYNTEX LAGOON, SPRINGFIELD, MO

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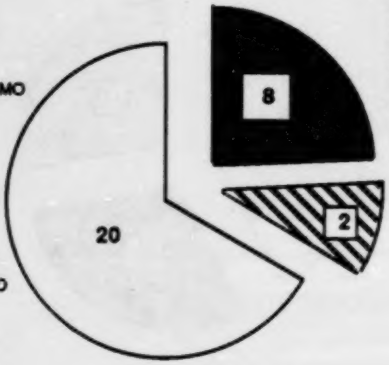
‡ IF A SITE UNDERWENT (OR IS ANTICIPATED TO UNDERGO) MORE THAN ONE ACTIVITY, THE MOST ADVANCED ACTIVITY IS INDICATED. SOME ACTIVITIES ARE ONGOING.

FIGURE 2-4

DISPOSAL SITES - 1A - MISSOURI WASTES RECEIVED FROM SPRAYING OF CONTAMINATED WASTE OIL

ACTIONS TAKEN TO DATE ‡



SAMPLED AND ANALYZED

ARKANSAS BEST FREIGHT, ST. LOUIS, MO
BAXTER GARDEN CENTER CHESTERFIELD, MO
BONFIELD BROTHERS TRUCKING,, ST. LOUIS, MO
BULL MOOSE TUBE CO., GERALD, MO
EAST TEXAS MOTOR FREIGHT, ST. LOUIS, MO
ERXLEBEN PROPERTY, ST. LOUIS, MO
OLD ACCESS ROAD, HWY. 141, MO
SOUTHERN CROSS LUMBER, HAZELWOOD, MO

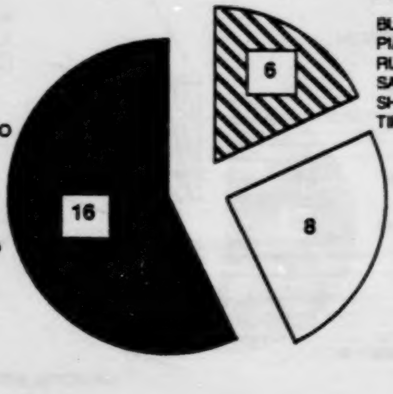
REMOVALS/REMEDIAL ACTIONS

BLISS PROPERTY, ELLISVILLE, MO
BUBBLING SPRINGS ARENA, FENTON, MO
CASHEL RESIDENCE, FENTON, MO
COMMUNITY CHRISTIAN CHURCH, MANCHESTER, MO
EAST NORTH STREET, EUREKA, MO
JONES TRUCK LINES, ST. LOUIS, MO
LACY MANOR DRIVE, CEDAR HILL, MO
MINKER RESIDENCE, IMPERIAL, MO
OVERNITE TRANSPORTATION, ST. LOUIS, MO
PIAZZA ROAD, ROSATI, MO
QUAIL RUN MOBILE PARK, GRAY SUMMIT, MO
ROMAINE CREEK, IMPERIAL, MO
RUSSELL BLISS FARM ROAD, ROSATI, MO
SADDLE AND SPUR RIDING CLUB, HIGH RIDGE, MO
SHENANDOAH STABLES, LINCOLN CO., MO
SONTAG ROAD, CASTLEWOOD, MO
STOUT RESIDENCE, IMPERIAL, MO
SULLINS RESIDENCE, IMPERIAL, MO
TIMBERLINE STABLES, CALLOWAY, MO
TIMES BEACH, MO

ENGINEERING ASSESSMENT

HAMILL TRANSFER CO., ST. LOUIS, MO
MANCHESTER METHODIST CHURCH, ST. LOUIS, MO

ACTION PLANNED OR ANTICIPATED ‡



ENDANGERMENT ASSESSMENTS PENDING LITIGATION

BUBBLING SPRINGS HORSE ARENA, JEFFERSON CO., MO
PIAZZA ROAD, ROSATI, MO
RUSSELL BLISS FARM ROAD, ROSATI, MO
SADDLE AND SPUR RIDING CLUB, HIGH RIDGE, MO
SHENANDOAH STABLES, LINCOLN CO., MO
TIMBERLINE STABLES, CALLAWAY CO., MO

MONITORING

ARKANSAS BEST FREIGHT, ST. LOUIS, MO
BAXTER GARDEN CENTER, CHESTERFIELD, MO
BONIFIELD BROTHERS TRUCKING, ST. LOUIS, MO
BULL MOOSE TUBE CO., GERALD, MO
CASHEL RESIDENCE, FENTON, MO
COMMUNITY CHRISTIAN CHURCH, MANCHESTER, MO
EAST NORTH STREET, EUREKA, MO
ERXLEBEN PROPERTY, ST. LOUIS CO., MO
HAMILL TRANSFER CO., ST. LOUIS, MO
JONES TRUCK LINES, ST. LOUIS, MO
LACY MANOR DRIVE, CEDAR HILL, MO
MANCHESTER METHODIST CHURCH, ST. LOUIS, MO
QUAIL RUN MOBILE PARK, GRAY SUMMIT, MO
OVERNITE TRANSPORTATION CO., ST. LOUIS, MO
SOUTHERN CROSS LUMBER, HAZELWOOD, MO
SULLINS RESIDENCE, FENTON, MO

REMOVALS/REMEDIAL ACTIONS

BLISS PROPERTY, ELLISVILLE, MO
EAST TEXAS MOTOR FREIGHT, ST. LOUIS, MO
MINKER RESIDENCE, IMPERIAL, MO
OLD ACCESS ROAD, HWY. 141, MO
ROMAINE CREEK, IMPERIAL, MO
SONTAG ROAD, CASTLEWOOD, MO
STOUT RESIDENCE, IMPERIAL, MO
TIMES BEACH, MO

‡ IF A SITE UNDERWENT (OR IS ANTICIPATED TO UNDERGO) MORE THAN ONE ACTIVITY, THE MOST ADVANCED ACTIVITY IS INDICATED. SOME ACTIVITIES ARE ONGOING.

Several of the Agency's actions are considered temporary solutions. These actions were taken to mitigate the immediate threat of public exposure. Temporary solutions normally contain rather than reduce, destroy, or permanently dispose of contaminated material. Permanent solutions may be undertaken in the future.

The Agency's planned or anticipated activities focus on permanent remedies. As discussed in Chapter 6, EPA is currently funding several demonstration projects aimed at developing effective and affordable treatment technologies. EPA's mobile incinerator has successfully treated Missouri soils, achieving 99.9999 percent destruction and removal efficiency. EPA has issued regulations under RCRA (see Chapter 5) specifying procedures for approving dioxin treatment and disposal facilities; however, there are currently no approved commercial treatment and disposal facilities for dioxin.

Most of EPA's cleanup activities discussed above were based on CDC or NIOSH health recommendations. NIOSH and CDC have issued recommendations concerning at least 37 residential, recreational, and commercial sites. These sites are listed in Table 2-3.

Health recommendations were issued for 16 residential and 7 public access area sites. Each site had been contaminated by dioxin-containing oil sprayed to control dust, or by oil-contaminated fill dirt. Of the 16 residential areas, residents of 6 of the sites have been advised to avoid contact with soil until cleanup or removal takes place. Access to portions of six additional sites is restricted until cleanup or removal. Evacuation and prohibition of use have been advised at the remaining four residential sites, the most notable being Times Beach, Missouri. An evacuation has been established, and many of the residents are complying.

For public access areas, access has been limited to a portion of the area at one park pending further testing. Two churches have been permitted to continue operations (including day-care center operations), provided access is limited at a remote area of each site. Due to the potential of soil disturbance and dust generation at riding stables, four stables require remedy; their use is currently restricted.

CDC and NIOSH issued health recommendations for 14 industrial sites, 11 of which are commercial facilities involved in light industry. Most of these sites were contaminated by dioxin-containing oil used for dust control. Seven of the 11 were found to present no hazard to the employees under current operating conditions. However, if activities which will disturb the soil occur (such as excavation or underground pipeline repair), safety precautions including protective clothing and respirators should be used. At an eighth commercial site which required cleanup, operations were permitted to resume. Access has been prohibited at a waste-oil storage facility until cleanup. At the tenth site, EPA expects responsible parties to mitigate all exposure routes. At the eleventh site (Nalco-tier 3), public access is restricted until additional samples are analyzed.

Health recommendations were issued for three tier 1 and 2 production facilities. One site has been found to pose no major hazard under current operations. The second site is not currently used, and access has been limited until cleanup. The third site ceased operations in 1982.

TABLE 2-2
SITE LISTING
NATIONAL DIOXIN STRATEGY
2/87

Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Tier 1				
		REGION I		
Baird & McGuire	Holbrook, MA	96 on-site soil	n.d.-48	Prior to dioxin discovery, removal of 1000 yd^3 of soil, installed ground water recirculation system and clay cap. Fence erected by EPA after dioxin discovery. New 12" water-main built to reroute water supply around site.
		17 off-site soil	n.d.	
		2 on-site sediment	n.d.	
		5 off-site water	n.d.	
		18 on-site soil	n.d.-11.3	
		5 on/off-site air	n.d.	
		35 on/off-site fish	n.d.-.0045	
		REGION II		
Chemical Insecticide	Edison, NJ	61 on-site soil	0.09-17	Fence installed. On-site and off-site sampling of air, soil, groundwater, surface water and other materials planned.
		80 off-site soil	<1.0	
Diamond Alkali	Newark, NJ	9 on-site soil	60-51,000	Tarp placed over on-site contamination areas and fence installed in back of property. Adjacent residential areas vacuumed and swept.
		537 off-site soil	n.d.-725	
		28 off-site vacuum bogs	n.d.-5.8	
		32 off-site sediment	n.d.-6.7	
Givauden	Clifton, NJ	37 on-site soil	n.d.-9.7	None to date; consent decree under negotiation to conduct RD/RA.
		28 off-site soil	n.d.	
Hooker Chemical (Buffalo Ave.)	Niagara Falls, NY	17 on-site soil	n.d. - 18,600	Access limited, areas covered, some waste containerized. Results of sampling transmitted to EPA RCRA and State for enforcement activities.
		4 off-site soil	n.d. - 1.1	
		5 on-site	4.6 - 524	
		2 off-site sediment	? - 8.6	

SITE LISTING
NATIONAL DIOXIN STRATEGY
2/87

Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Olin Chemical Corp.	Niagara Falls, NY	15 on-site soil 2 off-site soil	n.d. - 8.7 n.d.	Future action pending; additional sampling will be conducted. (still negotiating)
Tier 2				
Eastman Kodak	Rochester, NY	23 soil 2 sediment	n.d. n.d.	No further action planned.
Millmaster Onyx	Berkeley Heights, NJ	25	n.d - 0.7	No further action planned.
Tier 1a				
Brady Metals	Newark, NJ	10 on-site soil 30 off-site soil 14 on-site vertical soil 14 on-site surface wipe 3 on-site sweeping	1.9-3500 1.7-1156 0.95-1900 12-56 ng 5.4-16	Impermeable barriers, filters, and fence installed; responsible party performing clean-up.
Chemtrol/SCA Services	Model City, NY	?	0.001	None to date; preliminary dioxin screening planned.
Hooker Chemical (S-Area)	Niagara Falls, NY		-	Area fenced; surveys and studies phase of program begun. Site barrier wall, drain collection system, cap to be installed. All work governed by Consent Decree; no dioxin sampling per this decree.
Hooker Chemical (Love Canal)	Niagara Falls, NY	? on-site soil ? off-site sediment ? off-site soil (subsurface) ? off-site sewer	?-6.7 ?-45.8 ?-1.6 ?-650	Cap with synthetic liner installed. Leachate collection system creeks to be cleaned. Parts of sewers cleaned; rest to be cleaned later. Long-term monitoring program being implemented. RI/FS being conducted.

SITE LISTING
NATIONAL DIOXIN STRATEGY
2/87

Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Hooker Chemical (102nd Street)	Niagara Falls, NY	10 on-site surface soil 14 on-site subsurface soil	0.59 173-630	Area fenced; warning signs posted; RI/FS being conducted.
Hooker Chemical (Hyde Park)	Town of Niagara, NY	1 on-site non-aqueous phase liquid 20 off-site soil 1 off-site ground water	20,600 3-263 0.00018	Site is capped, fenced, and has a tile drain system nearby; planned collection of leachate by purge and recirculation wells.
Toscano Trucking	none to date	-	-	None to date; no specific site identified yet; no future activities planned.
Tier 2a				
Green Village Disposal	Green Village, NJ	?	n.d.	None to date. Responsible party search and dioxin screening completed. Dioxin was undetected in all samples.

REGION III

Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Tier 1				
Drake Chemical	Lock Haven, PA	-	n.d.	Site is fenced; drummed materials and reactor vessels removed and disposed; no additional dioxin response actions necessary.
Rohm & Haas	Bristol, PA	various (ca. 300)	?-3	Buildings vacummed; waste drummed and removed for incineration; no further actions necessary.
Union Carbide-SC	South Charleston, WV	-	n.d.	No further action necessary.

SITE LISTING
NATIONAL DIOXIN STRATEGY
2/87

Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Tier 2				
Amchem	Ambler, PA	9 on-site soil 1 on-site pipe dust 11 off-site soil 1 on-site sump	n.d.-118.0 609.9 n.d. 1.3	Buildings vacummed; waste being drummed and removed for incineration.
Artel Chemicals	Nitro, WV	189 on-site soil 6 on-site drummed waste 30 off-site soil	n.d.-18.8 1.78-1.94 n.d.	Planned coverage with asphaltic concrete cap; planned proper storage of contaminated drums.
Monsanto	Nitro, WV	Ca. 400 on-site soil Ca. 50 off-site soil	n.d.-400 n.d.-1.8	Area covered with asphalt, clay or gravel; building vacuumed, and waste drummed and removed for incineration; no further action necessary.
Tier 2a				
Boyerton Scrap	Boyerton, PA			All potentially contaminated waste was bagged on receipt and land-filled; dioxin project terminated.
Chem Clear	Chester, PA	Not tested		No method available to trace wastes; contamination not found in waste at Tier 2 site.
Colwell Lane	__________, PA			Drums buried on site; no further action necessary unless drums removed from site.
Georges Creek	Poca, WV	-	n.d.	No further actions necessary.
GROWS	Morrisville, PA	-	n.d.	No further actions necessary.
Heizer Creek	Poca, WV	19 on-site soil	n.d.-1.10	RI/FS underway.
Manila Creek	Poca, WV	19 on-site soil	n.d.-57.2	Remedial order planned.

SITE LISTING
NATIONAL DIOXIN STRATEGY
2/87

Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Monsanto Landfill	Nitro, WV	See Monsanto (Tier 2)		No further actions necessary.
Moyers Landfill	Collegeville, PA	-	-	No further actions necessary.
Nitro Dump	Nitro, WV	6 on-site soil	n.d-1.8	Capping completed.
Poca Landfill	Poca, WV	9 on-site soil	n.d.-17.8	Negotiation underway for RI/FS.
South Charleston Landfill	South Charleston, WV	-	-	No further actions necessary.
Washington Iron & Metal	Philadelphia, PA	Not tested		Metal melted down; no way to trace potentially contaminated metal.
		REGION IV		
Tier 2a				
Chemical Waste Management	Emelle, AL	None to date for TCDD except for PCB storage tanks		Facility referred to RCRA program for permitting action.
		REGION V		
Tier 1				
Dow Chemical Co.	Midland, MI	43 on-site soil (1984 study) 11 off-site soil 45 fish 106 on-site soil (1985 study) 42 off-site soil	0.041-52.0 0.0006-0.45 0.012-0.53 n.d.-1500 0.003 - 2.03	Contaminated debris removed and site capped; responsible party RCRA compliance plan under review. Corrective action investigations for three point source areas are under discussion.

SITE LISTING
NATIONAL DIOXIN STRATEGY
2/87

Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Tier 1a				
Poseyville Landfill	Midland, MI			Monitoring on a quarterly basis; closure of landfill. Responsible party RCRA compliance plan under review.
		REGION VI		
Tier 1				
Vertac	Jacksonville, AR	320 off-site various 45 on-site soil/sediment 26 fish 5 on-site water ? on-site wastes from 2,4,5-T production	<1-33.4 <1-1,200 n.d.-.798 n.d. up to several ppm	Wastes contained on-site with slurry walls, French drains and clay caps; off-site RI/FS being conducted.
Tier 1a				
BFI (CECOS Int'l)	Livingston, LA	none to date		No further dioxin action necessary; under RCRA enforcement program.
Chemical Waste Management, Inc.	Port Arthur, TX	none to date		Continued groundwater sampling, under RCRA, landfill closed, capped and graded.
Tier 2a				
Calgon Corporation	Pasadena, TX	1 on-site sludge 1 on-site reactor influent 1 off-site spent carbon	n.d. n.d. n.d.	No further action necessary.

SITE LISTING
NATIONAL DIOXIN STRATEGY
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Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
		REGION VII		
Tier 1				
Syntex Agribusiness	Verona, MO	74 on-site soil 14 on-site water 3 off-site water	n.d.-979 n.d.-41 <1.0	Responsible party planning removal action.
Tier 1a				
Arkansas Best Freight	St. Louis, MO	25 on-site soil 1 off-site soil	n.d.-5.8 n.d.	City to continue observation of site.
Baldwin Park	Aurora, MO	67 on-site soil 5 on-onsite sweep	n.d.-743 n.d.	Access roads barricaded and area posted. Site clean-up under negotiation.
Baxter Garden Center	Chesterfield, MO	19 on-site soil	n.d.-82	State to continue observation of site.
Russell Bliss Farm Road (=Piazza Road)	Rosati, MO	7 on-site soil	n.d.-382	RI/FS under development.
Bliss Property	Ellisville, MO	74 on-site soil 2 off-site	n.d.-120 n.d.	Creek bank stabilization and stream reroute on-going. RI/FS report completed; RD/RA underway.
Bliss Tank Property	Frontenac, MO	50 on/off-site soil 16 on/off-site sediment 13 off-site dust	n.d.-430 n.d.-14.4 n.d.	Contaminated soil paved; area is posted.
Bonifield Brothers Trucking	St. Louis, MO	5 on-site soil	12.9-55.8	City to continue observation of site.
Browning-Ferris Industries (BFI)	Missouri City, MO	Quarterly groundwater monitoring	n.d.	Site transferred to RCRA program for further action.
Bubbling Springs Arena	Fenton, MO	11 on-site soil 7 on-site sediment	n.d.-95 1-22	Contaminated soil excavated; RI/FS under development.
Bull Moose Tube Company	Gerald, MO	106 on-site soil 6 on-site sediment 6 on-site dust	n.d.-29.0 n.d. n.d.	State to continue observation of site.

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Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Cashel Residence	Fenton, MO	82 on-site soil 3 off-site dust	n.d.-250 n.d	Contaminated soil bagged and removed; site restored. Final management of soil pending.
Community Christian Church	Manchester, MO	134 on-site soil 2 on-site soil	n.d.-230 n.d.	Area paved; State to continue observation of site.
Denney Farm	Aurora, MO	? on-site oil ? on-site soil, solids, solvents	up to 2,000,000 up to 2,000	Site is current location of EPA mobile incinerator
East North Street	Eureka, MO	107 on-site soil 1 off-site soil 1 on-site dust	n.d.-6 n.d. n.d.	Road was regraded and repaved with asphalt; State to continue observation of site.
East Texas Motor Freight	St. Louis, MO	71 on-site soil 4 on-site dust 50 off-site sediment	n.d.-51.8 n.d.-1.5 n.d.- 20	Responsible parties to implement response action. Sampling to determine extent of contamination.
S.B. Erwin Farm	Verona, MO	20 on-site soil	n.d.-3.3	Area fenced; soil excavated and removed for incineration; site restored.
Erxleben Property	Glencoe, MO	129 on-site soil 1 on-site dust	n.d.-280 n.d.	Site posted; State to continue observation. Additional sampling to define extent of contamination to be conducted.
Hamill Transfer Company	St. Louis, MO	145 on-site soil 1 on-site sediment 4 on-site dust	n.d.-155 n.d. n.d.	None to date; city to continue observation.
Jones Truck Lines	St. Louis, MO	5 on-site soil	7.9-22.0	Area paved and building decontaminated.

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Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Lacy Manor Development	Cedar Hill, MO	102 on-site soil 5 on-site dust	n.d.-48.0 <1.0	Portion of area excavated, portion paved; residence decontaminated.
Manchester United Methodist Church	Manchester, MO	121 on-site soil 3 on-site dust	n.d.-5.4 n.d.	State to continue observation of site.
Minker Residence	Imperial, MO	289 on-site soil 16 on-site dust 21 on-site sediment	n.d.-340 n.d.-1.90 n.d.-210	Permanent relocation of residents; drainage diversion; excavation of contaminated soil. Final management of soil pending.
National Industrial Environmental Services (NIES)	Furley, KS	12 on-site monitoring well waste 39 on-site other	n.d.-1.8 n.d.	Landfill capped; monitoring wells sampled monthly; extraction wells installed. Evaporation ponds fluid treated; disposal cell being build for evaporation ponds sludges.
Neosho Digester	Neosho, MO	10 on-site soil	<1.0	Area fenced and posted; ground-water monitoring system to be installed. Soils incinerated.
Neosho Tank Water and Wastewater Technical School	Neosho, MO	41 on-site soil	n.d.-33.0	Soils excavated and drummed; drums were placed in bunker on-site and were then incinerated off-site.
Overnite Transportation Company	St. Louis, MO	180 on-site soil	n.d.-17	Site paved; periodic observation.
Piazza Road	Rosati, MO	360 on-site soil 105 on-site discrete soil 71 on-stie sieved 19 on-site sediment 5 on-site dust 2 on-site pond water 2 on-site pond sediment 5 on-site drainage 3 on-site bark 1 on-site rec. vehicle	n.d.-1,800 n.d.-1,020 n.d.- 611 n.d.- 165 n.d.- 18 <1.0 n.d.- 29 n.d.- 21 n.d.- 1.4 1.9	Area barricaded and posted; road excavated and paved; relocation offered; anticipate incineration of drummed soil off-site.

SITE LISTING
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Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Quail Run Mobile Home Park	Gray Summit, MO	341 on-site soil 42 on-site dust	n.d.-1,650 n.d.-11	Mobile homes being decontaminated, and contaminated soil being excavated. Site restoration nearing completion.
Bill Ray Farm	Verona, MO	various on-site	<20-160.0	Drums removed; no further action necessary.
Romaine Creek	Imperial, MO	251 on-site sediment 8 on-site soil 2 on-site water	n.d.-272 n.d.-50 n.d.	Drainage diversion constructed at Minker. Anticipate excavation and storage of contaminated soils.
Robert Rusha Farm	Barry County, MO	8 on-site soil	n.d.-4.5	Soil to be excavated and removed for incineration.
Saddle and Spur Riding Club	High Ridge, MO	91 on-site soil	n.d.-31	Area covered with sand; site fenced, posted, and inspected weekly.
Shenandoah Stables	Moscow Mills, MO	19 on-site soil 3 on-site dust 1 on-site water 3 on-site sediment 2 off-site water	n.d.-1,750 n.d.-110 n.d. n.d. n.d.	Site fenced and posted; RI/FS under development.
Sontag Road	Ballwin, MO	756 on-site soil 53 on-site dust 2 on-site water 2 on-site insulation 10 on-site sediment	n.d.-588 n.d.-36 n.d 1.0 n.d. - 1.4	Immediate removal action approved for excavation and containment of contaminated soil. All material will be stored on-site.
Southern Cross Lumber	Hazelwood, MO	11 on-site soil	n.d.-27.3	State to continue monitoring.
Spring River	Verona, MO	60 fish 13 sediment	n.d.-55 ppt. n.d.-12 ppt.	Continued fish and sediment monitoring.

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NATIONAL DIOXIN STRATEGY
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Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Stout Residence	Imperial, MO	374 on-site soil	n.d.-241	Restricted access, area posted; relocation offered; soil excavation under evaluation.
		7 on-site dust	n.d.	
Sullins Residence	Fenton, MO	57 on-site soil	n.d.-820	Access restricted; soil excavated; site restored. Final management of soil pending.
		3 on-site water	n.d.	
		2 on-site dust	n.d.	
		3 on-site sediment	n.d.	
Syntex Agribusiness	Verona, MO	See Tier 1		
Syntex Facility	Springfield, MO	4 on-site sludge	1-8	Sludge removal completed.
		1 on-site supernatant	<1.0	Sludge stored in concrete storage tank. Sludges schedule for incineration.
		1 on-site sludge (pretreatment)	1.5	
		3 on-site chamber water (pretreatment)	<1.0	
		1 on-site lift pump (pretreatment)	<1.0	
		5 on-site pilot plant	n.d - 5.9	
		15 on-site lagoon wells	<1.0	
		5 on-site monitoring wells	<1.0	
Royal Talley Farm	Marionville, MO	15 on-site soil	n.d. - 16.2	Soil excavated and transported for incineration.
Timberline Stables	New Bloomfield, MO	24 on-site soil	n.d.-42	Site fenced and posted; RI/FS under development.
		3 on-site dust	n.d.-53	
		2 on-site sediment	n.d.	
Times Beach	Times Beach, MO	451 on-site soil	n.d.-1,200	Residents relocated; levee constructed; town barricaded and guarded.
		90 on-site sediment	<1.0	
		13 on-site dust	<1.0	
		84 on-site water	n.d.-1.8	
		2 on-site storm water	<1.0	
		10 on-site surface debris	<1.0	
		96 on-site test pit-soil	n.d -404.0	
Tier 2				
Monsanto Company Queeny Plant	St. Louis, MO	3 on-site soil	n.d.	Buildings being decontaminated. Final clean-up anticipated soon.
		21 on-site dust	n.d.-4.8	

SITE LISTING
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Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Superior Solvents and Chemicals Company	St. Louis, MO	48 on-site soil 2 off-site soil 1 on-site sediment	n.d.-160 <1.0 <1.0	RI/FS to be negotiated.
Thompson-Hayward Chemical Company	Kansas City, KS	46 on-site soil 1 off-site soil 5 on-site dust 3 on-site wipe 1 on-site sludge 10 on-site water 1 off-site water	n.d.-46 n.d. n.d.-3.60 n.d n.d. n.d. n.d.	Some areas paved; dust suppressants applied; area fenced and posted; processing building to be sealed, remaining areas to be paved, groundwater to be sampled.
Tier 2a				
Browning Ferris Industries (BFI)	Missouri City, MO	-	n.d.	Site tranferred to RCRA program for further action.
National Industrial Environmental Services (NIES)	Furley, KS	See Tier 1a		
Conservation Chemical Company	Kansas City, MO	61 on-site soil	n.d.-29	Site fenced; cap, slurry wall, withdrawal well system, well water treatment system to be installed.
Wheeling Disposal	Amazonia, MO	none to date		Groundwater monitoring planned.
		REGION X		
Tier 2				
Rhone Poulenc	Portland, OR	several soil, sediment, and ground water	n.d.	No further EPA action necessary. State pumping treating contaminated ground water; continues to monitor the site.

SITE LISTING
NATIONAL DIOXIN STRATEGY
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Name	Location	No. And Kind Of Sample Analyzed	Concentration Range (ppb)	Response Actions
Tier 2a				
St. Johns Landfill	Portland, OR	34 samples (including groundwater, soil/refuse, leachate, gas)	n.a.	State responsible for monitoring site. Samples not tested for TCDD due to low levels of pesticide indicators (silvex, 2,4D).
Alkali Lake	Southeastern, OR	40 on-site soil 11 on-site ground water	.007-.063 n.d.	State owned property.
Resource Recovery	Pasco, WA	14 ground water and 20 soil samples	n.a.	No further on-site action necessary. State monitors the site. EPA sampling off-site drinking wells.
Western Processing Co.	Kent, WA	35 on-site tank several on- and off-site soil	n.d.-7.7 n.d.	Contaminated materials drummed and secured on-site. Liquid dioxin dechlorinated. Dioxin-free material incinerated and disposed off-site.
Envirosafe Services of Idaho, Inc.	Grandview, ID	various	n.a.	Ground-water sampling conducted.
Chemical Security Systems, Inc.	Arlington, OR	various	n.a.	Ground-water sampling conducted.

TABLE 2-3

DIOXIN SITES ISSUED HEALTH RECOMMENDATIONS

REGION	SITE NAME	LOCATION	AGENCY	ADVISORY
I	Baird & McGuire Site	Holbrook, MA	CDC	Recommendations issued after sampling is finished.
II	Diamond Shamrock	Newark, NJ	CDC	Limited access until cleanup.
V	Nalco Chemical Co.	Bedford Park, IL	CDC	Public access restricted until additional samples are analyzed.
VII	Arkansas Best Freight	St. Louis, MO	NIOSH	No modifications necessary.
VII	Baldwin Park	Aurora, MO	CDC	Continued monitoring, limited access.
VII	Baxter Garden Center	Chesterfield, MO	NIOSH	Normal activities may continue; excavation requires protective gear.
VII	Russell Bliss Farm Road	Rosati, MO	CDC	Avoid contact with soil.
VII	Bliss Property	Ellisville, MO	CDC	Mid-America arena is too contaminated for use.
VII	Bliss Tank Property	Frontenac, MO	CDC	Prohibited access.
VII	Bonified Brothers Trucking	St. Louis, MO	CDC	Site should remain unused.
VII	Bull Moose Tube Co.	Gerald, MO	NIOSH	Normal activities may continue; excavation requires protective gear.
VII	Cashel Residence	Fenton, MO	CDC	Soil should not be disturbed.
VII	Community Christian Church	Manchester, MO	CDC	Limited access to portion of property.
VII	East North Street	Eureka, MO	CDC	Limited access.
VII	East Texas Motor Freight	St. Louis, MO	NIOSH	Avoid contact with soil.
VII	S.B. Erwin Farm	Lawrence County, MO	CDC	Incinerate dioxin wastes above 50 ppm, remove soil to 50 ppt.
VII	Erxleben Property	St. Louis, MO	CDC	Evacuation and prohibition of use.
VII	Hamill Transfer Co.	St. Louis, MO	NIOSH	No dioxin hazard.
VII	Jones Truck Lines	St. Louis, MO	NIOSH	No hazard after clean-up.
VII	Lacy Manor Development	Cedar Hill, MO	CDC	Contact with soil should be avoided.

DIOXIN SITES ISSUED HEALTH RECOMMENDATIONS

REGION	SITE NAME	LOCATION	AGENCY	ADVISORY
VII	Manchester United Methodist Church	St. Louis, MO	CDC	Limited access to portion of property.
VII	Minker Residence	Imperial, MO	CDC	Residents are at health risk; relocation offered by EPA.
VII	Overnite Transportation Co.	St. Louis, MO	NIOSH	No dioxin hazard.
VII	Piazza Road	Rosati, MO	CDC	Contact with soil should be avoided; 3 families at risk.
VII	Quail Run Mobile Home Park	Gray Summit, MO	CDC	Contact with soil should be avoided.
VII	Romaine Creek	Imperial, MO	CDC	Access to fill area prohibited.
VII	Robert Rusha Farm	Barry County, MO	CDC	Incinerate dioxin wastes above 50 ppm.
VII	Saddle and Spur Riding Club	High Ridge, MO	CDC	Prohibited use.
VII	Shenandoah Stables	Lincoln County, MO	CDC	Facility should not be used.
VII	Sontag Road	Castlewood, Mo	CDC	Avoid contact with soil.
VII	Southern Cross Lumber	Hazelwood, MO	CDC	Normal activities may continue.
VII	Stout Residence	Imperial, MO	CDC	Residents are at health risk.
VII	Sullins Residence	Fenton, MO	CDC	Limited access to property.
VII	Royal Talley Farm	McKinley, MO	CDC	Site should not be used for cattle grazing.
VII	Timberline Stables	Callaway Co., MO	CDC	Those in contact with soil are at health risk.
VII	Times Beach	Times Beach, MO	CDC	Relocation of residents.
VII	Superior Solvents	St. Louis, MO	NIOSH	Normal activities may continue.

Chapter Three

TIERS 3, 5, 6, 7

The Office of Water coordinated the collection of over 4,000 samples from 862 sites nationwide. Regional, State and contractor personnel collected the samples. Sampled media included soil, sediment, fish, water, and various plants and animals.

The objective was to learn more about the extent of 2,3,7,8-TCDD contamination in the general environment. While tiers 1 and 2 sites were investigated with an expectation, based on experience, of finding contamination, tiers 3, 5, 6, and 7 were investigated with no such advance expectation. EPA defined these four tiers as follows:

Tier 3 -	Formulators, blenders, and packagers of 2,4,5-trichlorophenol (2,4,5-TCP)-based pesticides;
Tier 5 -	Sites where suspected contaminated pesticides were commercially applied;
Tier 6 -	Other chemical producers with a lower potential for contamination; and
Tier 7 -	Background sites.

As previously mentioned, the initial focus of tiers 3, 5, 6, and 7 was on 2,3,7,8-TCDD. The Strategy provided for testing for other congeners where appropriate; however, at the time the study was developed, there was a severe shortage of analytical methods, reference materials, and laboratories capable of testing for other congeners. Samples and/or extracts were saved to allow future analysis for other congeners. Follow-on work will take advantage of improvements in analytical capability.

Information for this chapter was derived from the more extensive report prepared by the Office of Water Regulations and Standards (EPA, 1987b).

3.1 Tier 3--Formulators

3.1.1 Objective

Tier 3 consisted of facilities (and associated waste disposal sites) where 2,4,5-TCP and its derivatives were formulated into pesticidal products. Generally, these products are herbicides, insecticides, fungicides and germicides:

Products	Uses
2,4,5-Trichlorophenol (2,4,5-TCP)	fungicide; bactericide
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	plant hormone; herbicide; defoliant
Silvex	herbicide; plant growth regulator
Erbon	herbicide
Ronnel	insecticide
Hexachlorophene	topical antiinfective (restricted); germicidal soaps; veterinary medicine
Isobac 20	topical antiinfective (restricted); germicidal soaps; veterinary medicine

The objective of the tier 3 sampling program was to determine the percentage of facilities that have concentrations of 2,3,7,8-TCDD above 1 ppb in soil, or at any detectable level in other environmental media (e.g., fish in nearby streams). The detection limits for other media, and therefore the levels that determine whether contamination is present, vary slightly from site to site.

3.1.2 Study Design

EPA statistically selected 61 formulator sites from the FIFRA and TSCA Enforcement System (FATES) data base. FATES contains the names of companies which have registered with EPA to engage in commercial activities with designated classes of chemicals. Regional Offices and States selected 23 additional sites for sampling.

Regional Offices sent information request letters to these facilities to verify existing EPA records on chemicals and their volumes, and to obtain additional information on the types and quantities of waste generated, waste disposal methods, and the location of disposal sites. In addition, regional personnel visited the selected sites prior to sampling to identify potential sampling locations. In some cases the information gathered through these efforts resulted in a decision not to sample a particular facility, either because the facility did not actually formulate the compounds of interest (13 ineligible sites) or because site reconnaissance revealed that the site was not suitable for sampling, e.g., extensive paving (7 eligible, missing sites). These 7 sites are considered missing for purposes of statistical analysis and are included in the statistical evaluation. Sampling was actually conducted at 41 of the statistically selected sites, and at all 23 of the regionally selected sites.

At each facility, targeted sampling was conducted in areas where contamination was considered most probable, including loading/unloading areas, storage areas, disposal areas, and storm water drainage areas. A random sampling scheme was developed for sites or portions of sites where there was not enough information to identify areas most likely to be contaminated.

3.1.3 Results

Results of the tier 3 investigation are portrayed in Figure 3-1. Soil contamination levels greater than 1 ppb were found at five of the statistically selected sites. Five additional sites had soil concentrations below 1 ppb.

2,3,7,8-TCDD was found in soil at a level greater than 1 ppb at five regionally selected sites. Four regional sites had soil levels below 1 ppb.

When found, contamination was usually limited within a site area. At three of the five statistically selected contaminated sites and four of the six contaminated regionally selected sites, only one or two samples had soil levels above 1 ppb.

2,3,7,8-TCDD was found in fish at 3 ppt at one statistically selected site, and at levels from 1-25 ppt in fish and sediment in a river adjacent to a regionally selected site. Soil samples were "non-detected" for these sites.

The one widely contaminated statistically selected site (13 of 14 soil samples with 2,3,7,8-TCDD at levels greater than or equal to 1.0 ppb) handled large quantities of 2,4,5-T, silvex and 2,4,5-TCP. The total amount handled was greater than 100,000 pounds. This site was already under investigation through the Superfund program when it was selected for this study. The one widely contaminated regionally selected site (16 of 26 soil and sediment samples at levels greater than or equal to 1 ppb) also handled 2,4,5-T and silvex, with the total amount handled greater than 100,000 pounds.

Based on the results of sampling at the statistically selected sites and using the assumption that the seven missing eligible sites are contaminated with similar frequency as the sites that were actually sampled, it is estimated that 12±8 percent of the 312 facilities in the FATES data base may be contaminated. It is important to note that this estimate is derived simply from whether any samples at a facility had levels greater than one part per billion. As discussed below, the number of positive samples at most sites was very limited.

These estimates do not necessarily apply to the 325 potential formulators identified from other sources. Fewer of these facilities are likely to have actually engaged in formulation activities (e.g., registered to handle the pesticide but never actually did so because of the 2,4,5-T cancellation proceedings).

EPA has identified 29 facilities in the FATES data base which handled more than 100,000 pounds of 2,4,5-T, silvex, and/or 2,4,5-TCP. EPA investigated 12 of these as part of this study, and is gathering information on the remaining 17 to determine if future sampling is needed.

Discussion of Contaminated Sites

During review of the sampling results, the appropriateness of EPA's soil sampling methodology was questioned. The specific issue was whether taking 4-inch core samples might have diluted the 2,3,7,8-TCDD levels to such an extent that low levels in the surface layer might not be detected.

EPA's work plans for soil sampling in tiers 3-7 were extensively peer-reviewed prior to implementation. Four-inch core samples were selected because a number of studies had shown that highest levels were most likely to be found in subsurface layers.

The Seveso, Italy accident involved airborne dispersal and deposition of contaminants. Subsequent investigation of the vertical distribution of 2,3,7,8-TCDD found that the highest levels were not found in the uppermost (0.5 cm) layer, but rather most often in the second (0.5-1.0 cm) or third (1.0-1.5 cm) layers (DiDomenico, et al., 1980).

Investigation of soil concentrations of 2,3,7,8-TCDD at Eglin AFB after aerial application of Herbicide Orange found the highest levels in the 2-4 inch layer (EPA, 1980).

Researchers have suggested that photolysis and other degradative processes, volatilization, and downward diffusion play varying roles in the vertical distribution of material.

During the investigation of DOW Midland and associated comparison sites, EPA collected a limited number of samples which were surficial in nature. The data from this effort are presented below. With the exception of the areas subject to the influence of the DOW plant, the results were comparable to those from tiers 3-7.

Surficial* Soil Sampling Conducted for the Midland, Michigan Study (2,3,7,8-TCDD)

Location	Number of Samples	Number of Detects	Range of Detects (ppt)	Range of Detection Limits for Non-detects (ppt)
Midland—Dow Plant	15	15	10-36,000	—
—Plant Perimeter	9	9	10-2,030	—
—Open Areas	22	21	3-110	1
—Downspouts	13	13	13-270	—
Upwind of Midland—Open Areas	3	0	—	2-4
—Downspouts	2	2	6-9	—
Middletown, Ohio	22	6	3-5	1-3
Henry, Illinois	13	1	2	1-3
Minnesota Natural Areas	4	0	—	1-3

*All samples taken to a depth of 0.5-1 inch.

Figures 3-1 and 3-2 and Table 3-1 summarize site results. Following is a narrative description of contaminated sites and sampling results. 2,3,7,8-TCDD was not detected at 43 of the 64 sites which were sampled. A summary of sampling activities at these sites is provided in the Tiers 3,5,6,7 Report (EPA, 1987b).

Region II * Farmingdale Garden Lab--Farmingdale, New York

This facility, located on 0.5 acres, blended and repackaged silvex from 1965 to 1978 and erbon in 1969. Over 90 percent of the site is covered by a building and pavement.

Twenty-five random soil samples were collected from a 10 by 75 ft gravel area at the rear of the processing building. One of these samples contained 2,3,7,8-TCDD at 17.6 ppb.

This site has been referred to Superfund and will be resampled under that program.

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* Statistically selected site.

Region II * Rockland Chemical Co., Inc. - West Caldwell, NJ

This facility, located on approximately 1.8 acres, formulated products containing silvex from 1961 to 1979 and products containing 2,4,5-T until 1976. There are currently five underground storage tanks on-site which are used for storing solvents. A septic tank was used for disposal of process waste and sanitary wastewater before the plant connected to a treatment facility.

Ten soil samples were collected along the perimeter of former and current loading docks where runoff from on-site loading and storage areas would collect. The one sample containing 2,3,7,8-TCDD (1.32 ppb) was collected down-gradient from the current loading dock area.

Additional sampling at the site indicated levels of 2,3,7,8-TCDD below 1 ppb at several storage and loading areas. The New Jersey Department of Environmental Protection is discussing possible remedial actions with the facility.

Region III R.H. Bogle Company--Alexandria, Virginia

This facility, located on five acres, distributed 2,4,5-T and silvex from 1954 to 1979. These herbicides were stored on-site and loaded into railroad sprayer cars for application to railroad rights-of-way. In 1978, most of the site was clay-capped to contain arsenic contamination. Residential townhouses, office buildings, and asphalt parking lots now cover the site.

As the site has been changed substantially in recent years, 40 soil samples were collected at 17 locations that had received runoff from the site prior to capping. No 2,3,7,8-TCDD was detected in any of these samples. However, five of the nine sediment samples taken from the Oronoco Bay and the Potomac Estuary, which border the site, contained 2,3,7,8-TCDD at levels of 5.5-23 ppt. Seven of the eight fish collected from the Potomac Estuary within 2 miles north of the site contained 2,3,7,8-TCDD at levels of 1.6-6.3 ppt. Since the samples containing 2,3,7,8-TCDD were collected off the site, there is no conclusive evidence that the contamination came from the Bogle facility.

The Centers for Disease Control concluded that no further sediment and fish sampling for 2,3,7,8-TCDD is required. EPA Region III is evaluating the impact that dredging may have on the bioavailability of 2,3,7,8-TCDD in the Potomac Estuary.

Region III * Holder Chemical Company--Ona, West Virginia

This facility, located on 2.5 acres, used a number of insecticides and herbicides, including 2,4,5-T, in formulating products. The years when 2,4,5-T was used in formulation are unknown. Based on a 1982 site evaluation, approximately 280 tons of contaminated topsoil containing malathion, chlordane, sevin, DDT, dieldrin, heptachlor, lindane, kepone, and 2,4-D were removed from the site (no dioxin analyses were performed).

Thirty-six soil samples were collected: 31 from locations surrounding the main building, and 5 from the wooded area bordering the site. No 2,3,7,8-TCDD was detected in any of these samples or in the five sediment samples and a clam sample collected from the nearby Mud River. However, all three fish samples collected from this river 0.5 miles downstream from the site contained 2,3,7,8-TCDD at levels between 0.5 and 2.9 ppt. There is no conclusive evidence that the contamination came from the Holder facility.

No followup action is planned for this site.

Region III Smith Douglas (Borden)--Norfolk, Virginia

This facility, located on 35 acres, formulated products using silvex. The formulation activity took place in two buildings.

Fifty-three soil samples were collected: 15 from around the storage building, 14 around the formulation building, 5 from ditches at the perimeter of the property, and 19 at various other locations around the site. Ten dust samples were also collected from the storage building and from the formulation building. A sample of trash from the formulation area was also analyzed. The one soil sample containing 2,3,7,8-TCDD (10.1 ppb) was collected along a driveway leading to the building where silvex was formulated. No 2,3,7,8-TCDD was detected in the dust or trash samples.

Intensive followup sampling under the Superfund program was conducted around the formulation building. The location of 2,3,7,8-TCDD contamination was confirmed, with no additional contaminated locations being identified. The company has agreed to excavate the contaminated soil and dispose of it along with the formulation equipment in a manner acceptable to EPA.

Region IV - Chem Spray--Belle Glade, Florida

This facility, located on two acres, formulated products using large amounts (more than 100,000 pounds) of 2,4,5-T from 1967 to 1977. A residue pile is adjacent to a formulation building. In addition, canals border two sides of the site.

Nineteen soil samples were collected: 2 from the residue pile, 4 from outside the formulation building, 2 from between the formulation building and a second building, and 3 from around this second building. Eight random samples were also taken between the two buildings. The two soil samples containing 2,3,7,8-TCDD (0.2 and 3.0 ppb) were both collected outside the second building. Seven sediment samples were also collected from canals. All contained 2,3,7,8-TCDD at levels between 20.9 and 515 ppt.

Additional sampling and analysis confirmed the isolated nature of the 2,3,7,8-TCDD contamination. The facility has secured the contaminated area. EPA is currently pursuing alternatives for disposal.

Region IV * Security Chem (Woolfolk Chem)--Fort Valley, Georgia

This facility, located on 22 acres, repackaged and stored silvex from 1978 to 1979, in a general warehouse which housed a loading dock.

Seventeen soil samples were collected: three from around and underneath the warehouse (the building is on raised blocks), three along the street where silvex was transported, five around another site building, five from various other site locations, and one from a drainage ditch. The soil sample containing 2,3,7,8-TCDD (23 ppb) was collected from underneath the warehouse where 55 gallon drums were stored. A field duplicate for the same sample contained 40 ppb. It appears that the contamination was due to spillage. The drainage ditch sample also contained 2,3,7,8-TCDD at 36.7 ppt.

Security Chemical, as the responsible party, and the Georgia Environmental Protection Division conducted a comprehensive sampling survey of the entire facility, confirming the isolated nature of the contamination. Appropriate measures have been taken to secure these areas. EPA is currently pursuing alternatives for disposal.

Region V * ETM Enterprises (Parsons Chemical Works, Inc.) Grand Ledge, Michigan

The facility, located on approximately five acres, formulated products using 2,4,5-T and ronnel for an unknown number of years, although the mixing, manufacturing, and packaging of agricultural chemicals at the site generally occurred from 1945-1979. Several areas of this site had previously been found contaminated with other pollutants, and some excavation of contaminated soil has taken place.

Twenty-one soil samples were collected: 7 from a storm-water drainage ditch, 2 from an area where a septic system had been removed as a result of previous sampling, 2 at the storm drain pipe (1 at the inlet and 1 at the open catch basin), 4 off the southwest corner of the building where previous sampling had indicated other pollutant contamination (no previous 2,3,7,8-TCDD analyses), 1 from just outside the parking lot, 4 along the south side of the building near the loading dock in a low area (under downspouts), and 1 near the mid-north side of the building along the roof drain line. The two samples containing 2,3,7,8-TCDD (0.56 and 1.13 ppb) were collected at two depths at the location where storm water from the storm drain pipe discharges into the drainage ditch.

Additional samples, collected and analyzed at lower levels of detection, contained 2,3,7,8-TCDD in sediments from a nearby stream and the Grand River, at levels of 9 and 15 ppt; soils on-site had levels between 0.005 and 0.246 ppb.

"*" denotes a statistically selected site.

The State of Michigan has fenced, covered and paved the drain outlet. A septic tank and surrounding soils have been removed. Plant floor drains have been closed. Additional remedial measures are being discussed by the company and the State.

Region V Nalco Chemical Company--Bedford Park, Illinois

This facility, located on approximately 21 acres, used large amounts of sodium 2,4,5-trichlorophenate (approximately 100,000 pounds) and 2,4,5-TCP (approximately 8,500,000 pounds). The 2,4,5-TCP was reported by one of Nalco's suppliers to contain a maximum of 0.098 ppm 2,3,7,8-TCDD. Formulation wastes were disposed of off-site with other soil waste from the plant, or with plant waste water which went to the sanitary sewers after treatment (removal of oils and solids). The sludge was temporarily stored on-site and then disposed of off-site in a landfill. Products not meeting specifications were stored on-site in 55-gallon drums and then disposed of off-site in a landfill.

This site is extensively paved. Ten soil samples were initially collected: 7 from loading docks, and 1 sample each from outside a warehouse, a processing building, and a storage building. These three samples were in areas of expected roof drainage. The two samples containing 2,3,7,8-TCDD (1.9 and 2.2 ppb) were collected at two of the loading docks, one at the drum rinsing operation location and the other at a processing location. Significant levels of other dioxin isomers were also found in one of those samples.

Additional sampling in areas adjacent to previously identified contamination and areas of expected drainage indicated the presence of 2,3,7,8-TCDD ranging from 0.24 to 5.2 ppb in all samples; significant levels of other dioxin and furan homologues were also found. Contaminated areas have been covered with plastic and gravel.

EPA issued a unilateral 106 Order under CERCLA to Nalco to investigate the extent of contamination and to take appropriate steps to prevent migration.

Region V * Riverdale Chemical Company--Chicago Heights, Illinois

This site formulated products using silvex, 2,4,5-T and 2,4,5-TCP, and had already been scheduled for investigation under the Superfund program prior to its statistical selection for this study. The sampling approach used at the site by the Superfund program was slightly different than those used at the other tier 3 sites.

Fifteen soil samples were initially collected by gridding and sampling all the open areas. Areas covered by gravel or pallets were not sampled. Widespread 2,3,7,8-TCDD contamination was found on-site; 13 of the 14 soil samples collected contained 2,3,7,8-TCDD at concentrations ranging from 1.1 to 364 ppb.

Two Consent Orders are being implemented by the Riverdale Chemical Company. The first involved covering the area where 2,3,7,8-TCDD was detected with tarp or gravel. The second requires Riverdale to conduct a remedial investigation/feasibility study of the site and its surrounding areas to determine the extent of contamination. This information will be used to develop further appropriate remedial action.

Region VII Union Carbide Agricultural Products Company Inc. (formerly Amchem Product Co.)--Saint Joseph, Missouri

This facility was owned by Amchem Product Co. when it formulated products containing 2,4,5-T and silvex. More than 100,000 pounds of these compounds were used in formulation from about 1957 until about 1978. Union Carbide purchased the facility from Amchem Products in 1978. This site is about seven acres, with about five acres of open fields.

Twenty-six soil samples were collected at this site: 4 from the railroad loading area, 4 from around a storage tank of 2,4,5-T, 8 from a bare spot where a spill may have occurred, and 10 from a drainage ditch that receives runoff from on-site loading and unloading areas. Valid analytical results were obtained for 25 of the 26 samples (questionable results were obtained from one of the drainage ditch samples). Of the 25 samples, detectable levels of 2,3,7,8-TCDD of 0.13-39.1 ppb were found in 23; values greater than 1 ppb were detected in 16. The highest concentrations were observed in soils taken from the bare spot.

After being notified of the results from the sampling, Union Carbide voluntarily installed a fence around the entire site in order to limit unauthorized access. The Superfund program requested Union Carbide to evaluate pollution abatement options. Additional samples were collected by EPA to determine the extent of pollution more accurately. Further cleanup negotiations are on hold pending review of analytical results from the additional sampling.

Region IX Magna Corp.--Sante Fe Springs, California

This facility, located on two acres, blended large amounts of 2,4,5-TCP (greater than 100,000 pounds) into products from 1961 to 1978.

Ten soil samples were collected along the perimeter of this facility where drainage would collect. The one sample containing 2,3,7,8-TCDD (2.0 ppb) was collected downgradient from the 2,4,5-TCP mixing area.

EPA issued an immediate removal order under Superfund. The company drummed all contaminated soil, sediment, and debris and conducted additional sampling in an off-site drainage ditch.

3.1.4 Findings

o Assuming that the 7 unsampled sites have the same frequency of contamination as sampled sites, EPA estimates that approximately 12 percent of the tier 3 facilities identified in the FATES data base would be found contaminated.

- At contaminated sites, the extent of contamination was usually limited to one or two soil samples with concentrations of 2,3,7,8-TCDD above 1 ppb. Only two tier 3 sites were extensively contaminated.
- All 12 contaminated sites were at or near facilities that handled 2,4,5-TCP, 2,4,5-T, and/or silvex.
- The two extensively contaminated facilities were both large handlers of 2,4,5-T, 2,4,5-TCP and/or silvex.

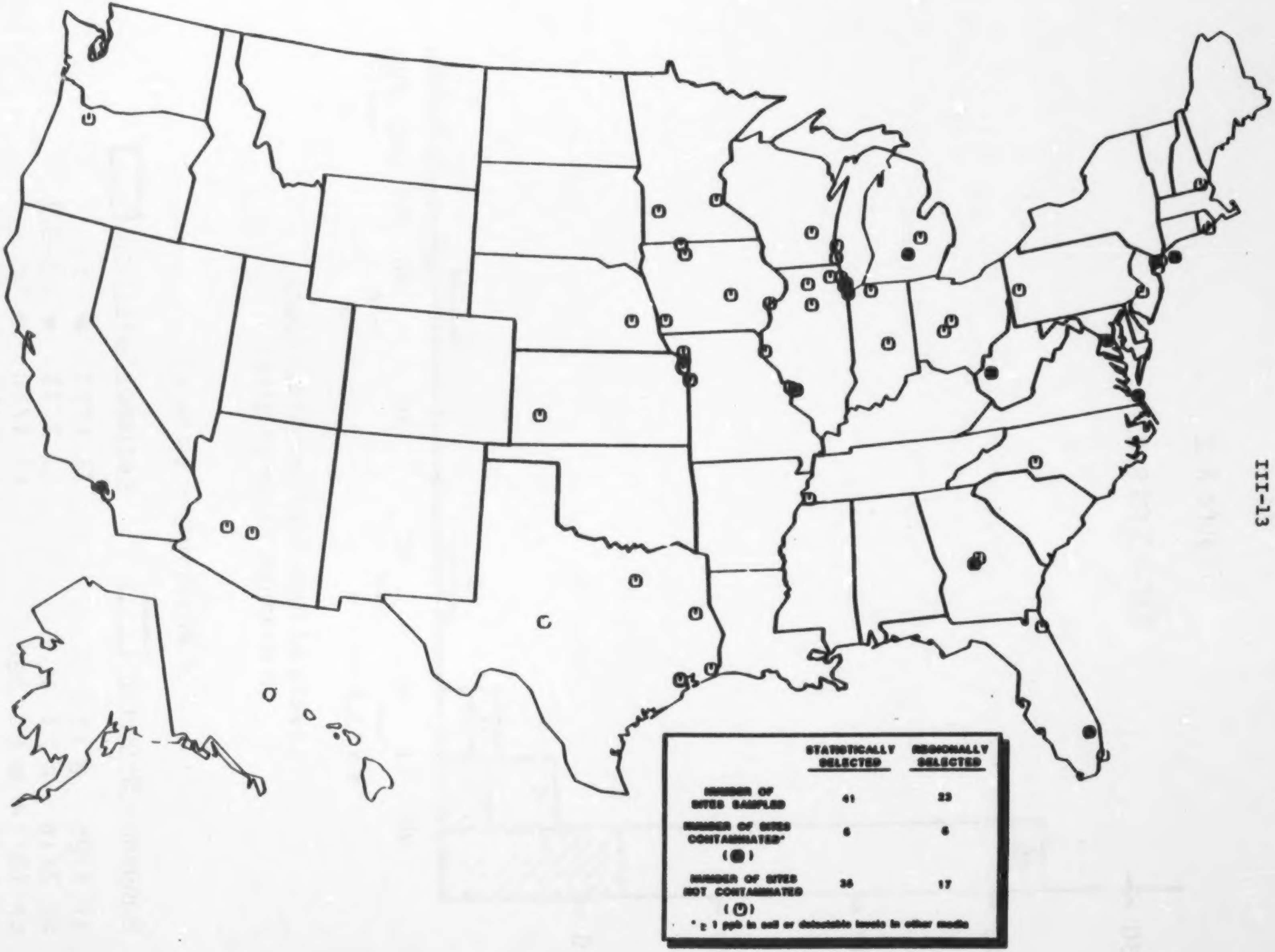
3.1.5 Conclusions

- Based on the limited number of sites found to be contaminated, the small number of positive samples at most of these sites, and the generally low levels of 2,3,7,8-TCDD detected, immediate national investigation of all of the remaining Tier 3 formulator facilities does not appear to be warranted.
- In addition to the facilities referred to Superfund for more immediate followup, the names of the remaining facilities have been transmitted to the Regional Offices with the request that they be added to CERCLIS, the Superfund facility list, for future Superfund attention.
- Since the two extensively contaminated facilities were both large handlers of 2,4,5-T, silvex, and/or 2,4,5-TCP, further evaluation of other large handlers of these three compounds is warranted. EPA sampled 12 of the 29 large handlers of these compounds as part of the study, and is collecting information on the remaining 17 facilities.

3.2 Tier 5--Use Sites

3.2.1 Objective

Tier 5 sites are areas where 2,4,5-TCP and pesticide derivatives (including 2,4,5-T and silvex) were used on a

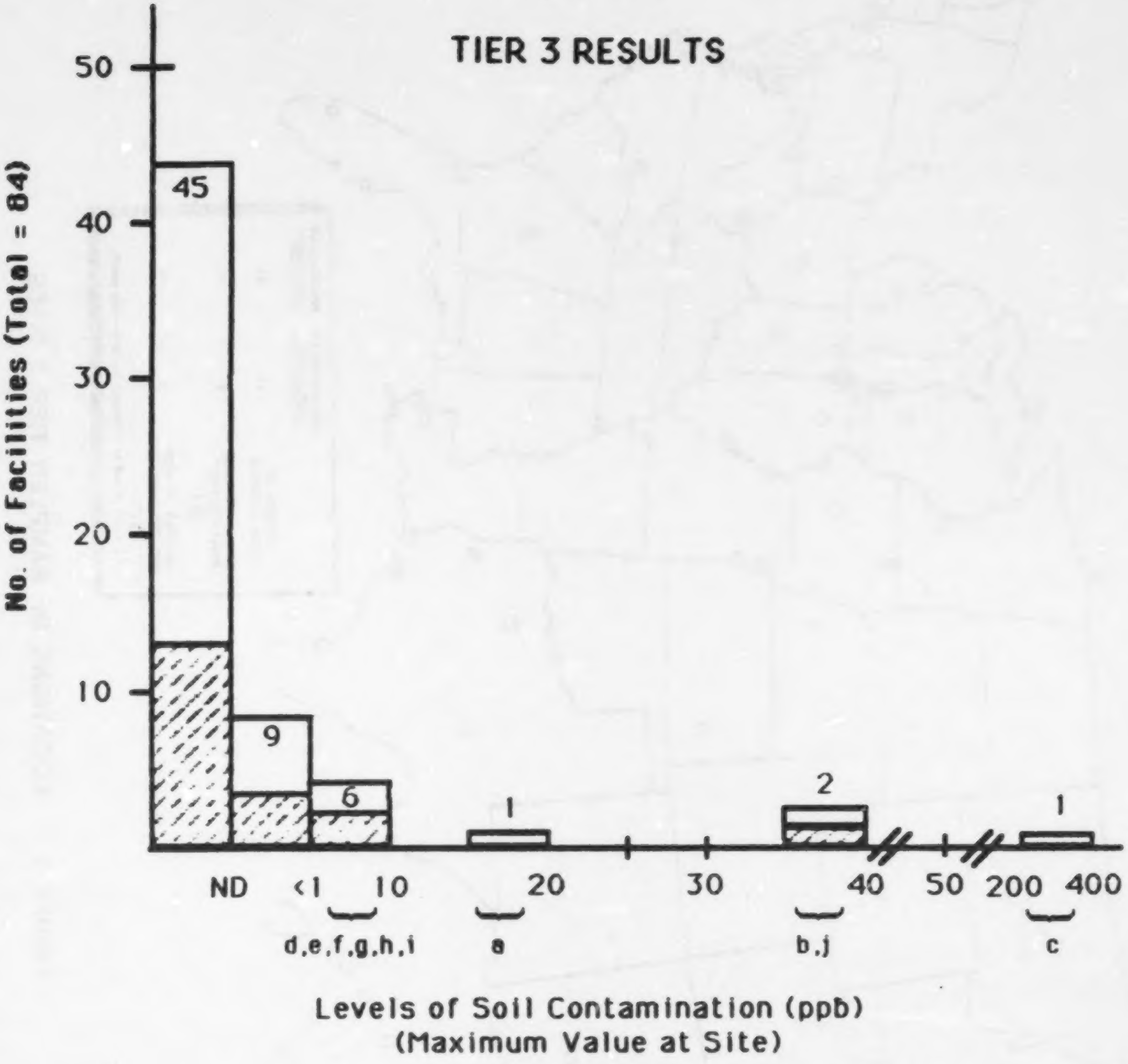


	STATISTICALLY SELECTED	REGIONALLY SELECTED
NUMBER OF SITES SAMPLED	41	23
NUMBER OF SITES CONTAMINATED* (●)	5	6
NUMBER OF SITES NOT CONTAMINATED (Ⓤ)	36	17

* ≥ 1 ppb in soil or detectable levels in other media

FIGURE 3-1. LOCATIONS OF SAMPLED TIER 3 SITES

Figure 3-2



TIER 3 RESULTS

POSITIVE/# SAMPLES

Randomly Selected ☐

a) 1/25 @ 17.6
b) 2/16 @ 23-40
c) 13/14 @ 1.1-364
d) 2/20 @ .56-1.13
e) 1/10 @ 1.3

Regional Selection ▨

f) 1/53 @ 10.1
g) 2/19 @ 1.9-3.2
h) 1/10 @ 2.0
i) 2/10 @ 1.9-2.2
j) 23/26 @.13-39.1

commercial basis. A statistical sampling of this tier was not possible due to the variety of uses and conditions. The objective was to determine whether 2,3,7,8-TCDD is present at detectable levels (approximately 1 ppt) in areas where major uses of these pesticides had occurred.

Tier 5 sampling was generally limited to those areas where the use of 2,4,5-T or silvex has been documented, since information from the Office of Pesticide Programs indicated that these two compounds have been more heavily used in specific areas and thus have a greater potential for causing significant human exposure to dioxin. The other compounds were of lesser interest due to: (1) low levels of active ingredient pesticide in the end-products; (2) use on very small areas; or (3) a wide diversity of uses at low levels of application. Lack of documentation of usage also made it impractical to focus on these other compounds.

3.2.2 Study Design

To identify applicable sites, the Office of Pesticide Programs compiled general information on areas of use for the pesticides of interest. EPA Regional Offices, in conjunction with state or local agencies, then identified the specific sites to be sampled.

A total of 26 tier 5 sites were sampled, including six forest sites, seven rice fields, three surgarcane fields, three rights-of-way, three rangeland areas, and four aquatic sites (used for recreation, fisheries, or multiple uses).

A random sampling approach was generally used to select the sampling locations at tier 5 sites. This approach assumed that "hot spots" could not be identified within a pesticide use site, and that the 2,3,7,8-TCDD is either uniformly or randomly distributed within the site. In a few cases, locations such as equipment loading areas or drainage ditches were targeted for sampling, since 2,3,7,8-TCDD contamination, if present, was expected to be higher in these areas.

The environmental media to be sampled were determined by the Regional Offices on a site-by-site basis. These included soils, stream sediments, fish tissue, vegetation, and animal tissue. All analyses were done at detection levels of approximately 1 ppt, because soil concentrations below 1 ppb can be of concern in certain types of areas, such as grazing lands.

3.2.3 Results

2,3,7,8-TCDD has been detected at 15 of the 26 sites including 2 rights-of-way, 1 aquatic use site, 2 sugarcane fields, canals adjacent to 1 sugarcane field, 4 rice fields, 3 forest areas, 1 rangeland area, and 1 multiple use area. More than 40 percent of the soil and sediment samples taken at contaminated sites had 2,3,7,8-TCDD present above the detection limit of approximately one ppt. Two sites had detectable levels in fish. At one of these, all fish samples were contaminated at levels up to 23 ppt in filets. 2,3,7,8-TCDD levels in soils at contaminated sites were between 0.6 and 6623 ppt with 67 percent below 5 ppt; levels in sediments were between 0.7 and 200 ppt with 61 percent below 5 ppt; and levels in fish filets were between 8 and 23 ppt. No 2,3,7,8-TCDD was detected in animal tissue or vegetation samples collected from land used for grazing or raising crops; however, only a limited number of these samples were collected.

CDC has indicated that 2,3,7,8-TCDD soil levels as low as 6.2 ppt may be of concern where dairy cattle graze. Levels of potential concern for soil where beef cattle graze range from 20 to 79 ppt. With the exception of the Tonto National Forest discussed below, grazing did not occur and/or levels detected were below the values suggested by CDC.

Discussion of Contaminated Sites

Figure 3-3 and Tables 3-2 and 3-3 summarize tier 5 site results. Following is a narrative description of the 15 contaminated sites. A summary of sampling results for the 11 sites where 2,3,7,8-TCDD was not detected may be found in the Tiers 3,5,6,7 Report.

Region I Grindstone, Maine

In 1977, approximately 1,000 acres of railroad yards and railroad rights-of-way were sprayed with a herbicide containing 2,4,5-T. A 16-foot area, 8 feet to each side of the centerline of the tracks, received the herbicide directly; an estimated 2 feet beyond this area on each side received the herbicide from aerial drift. An 1,800-foot long section of this right-of-way was sampled.

Twenty-two soil samples were collected approximately 2 feet from the ends of the rail ties. Eighteen of the 22 samples contained 2,3,7,8-TCDD at levels ranging from 8 to 35 ppt.

No additional action is planned at this time. The low ppt level contamination found is in the ballast or subgrade areas of an active railroad, and thus presents minimal risk.

Region II Long Island Railroad, New York

This railroad right-of-way was treated with 2,4,5-TCP based herbicides during the 1970's.

A 480-foot long section along the tracks was sampled. Twenty-six samples were collected 13 feet from each end of the tracks. One sample contained 2,3,7,8-TCDD at a level of 9 ppt.

No additional action is planned.

Region IV Cleveland, Mississippi

This ricefield was treated with 2,4,5-T in 1978, 1981, and 1984.

Twenty random soil samples were collected from a recently harvested field (60-100 acres). Sixteen samples contained levels of 2,3,7,8-TCDD at levels ranging from 0.8 to 1.7 ppt.

No additional action is planned.

Region IV Scot, Mississippi

This ricefield was treated with 2,4,5-T in 1984.

Twenty random soil samples were collected from a recently harvested field (60-100 acres). Two samples contained 2,3,7,8-TCDD at levels of 0.6 and 0.7 ppt. No 2,3,7,8-TCDD was detected in the one rice sample.

No additional action is planned.

Region IV West Palm Beach, Florida

These sugarcane fields were treated with silvex for weed control around the perimeter of the fields.

Sampling was not permitted directly on the sugarcane fields so sediment samples were collected from canals adjacent to the fields. Twenty-seven of 36 collected sediment samples contained 2,3,7,8-TCDD at levels ranging from 0.7 to 26.5 ppt.

EPA has notified the Florida Pesticide Enforcement Division of Inspection, Department of Agriculture and Commerce Services of the results.

Region V Petenwell Flowage, Wisconsin

This 23,000-acre reservoir on the Wisconsin River supported a major commercial carp fishery until 1983 when 2,3,7,8-TCDD was detected in carp at levels above 50 ppt. Chlorophenol-based slimicides, reportedly containing 2,3,7,8-TCDD as a contaminant, had previously been used by several pulp and paper mills along the river. Use of these slimicides had been voluntarily stopped by the mills by 1980.

Whole fish and filets from several species, fatty tissue from raccoons, aquatic bird tissue and eggs, aquatic sediments, and sludges from the paper mills were sampled. An information request was directed to each of the facilities in order to acquire more detail regarding past slimicide usage and sludge disposal practices.

All sampled fish contained 2,3,7,8-TCDD, with levels of 9-47 ppt in the whole fish and 3-23 ppt in the filets. Aquatic sediments at both ends of the reservoir contained 2,3,7,8-TCDD at levels from 35-200 ppt. Two of the paper mills are still producing sludges with 2,3,7,8-TCDD levels over 100 ppt, even though chlorophenol-based slimicides are no longer used. The chlorine-bleaching process has been identified as a potential source of 2,3,7,8-TCDD.

As a result of these findings additional work is being conducted at this site, with particular interest in determining the cause of 2,3,7,8-TCDD sludge contamination and environmental conditions at and near the sludge disposal sites. The industry has begun followup studies under State direction.

Region VI Assumption, Louisiana

This 2,500 acre site, used for growing sugarcane, was treated with silvex in 1983. Twenty-four soil samples were randomly collected from eight acres. Fourteen samples contained 2,3,7,8-TCDD at levels between 0.3 and 1.1 ppt.

No additional action is planned.

Region VI Desha County, Arkansas

This experimental agricultural station specializes in rice reproduction, with soybeans grown in rotation. Two 20-acre fields at this site were aerially sprayed with 2,4,5-T. One field was treated with 2,4,5-T in 1972, 1974, and 1975; the other was treated in 1975 only.

Forty-six soil samples were randomly collected from the 2 fields and associated drainage ditches. One sample from the field that had been treated three times contained 2,3,7,8-TCDD at 3 ppt. No 2,3,7,8-TCDD was detected in the five plant tissue samples or the three drainage ditch samples.

No additional action is planned.

Region VI Richland Parish, Louisiana

Approximately 70 acres of this ricefield were treated with 2,4,5-T, with one application in 1982 and two applications in

1983. Thirty-five samples and 1 sediment sample were randomly collected; 2,3,7,8-TCDD was detected in 9 soil samples at levels between 0.3 and 0.4 ppt. No 2,3,7,8-TCDD was detected in the sediment sample.

No additional action is planned.

Region VI Pointe Coupee Parish, Louisiana

This site, used for growing sugarcane prior to 1985 and soybeans in 1985, was treated with silvex in 1983.

Twenty-five soil samples were randomly collected from two fields, 2.6 acres and 2.7 acres in area. Twenty samples contained 2,3,7,8-TCDD at levels ranging from 1.0 to 2.5 ppt.

No additional action is planned.

Region VI Rio Grande Plain Experimental Ranch, Kinney Co., Texas

This site is an experimental ranch used for research on brush control and livestock production. In 1981, parts of three experimental pastures (five acres each) were aerially sprayed with 2,4,5-T. Parts of each were left untreated as controls.

Thirty-eight soil samples were randomly collected from the three pastures among the treated and untreated areas. Twelve samples contained 2,3,7,8-TCDD--5 samples from treated areas and 7 samples from untreated areas--at levels between 0.2 and 3 ppt. No 2,3,7,8-TCDD was detected in a rattlesnake or in six vegetation samples collected from the sprayed pastures.

No additional action is planned.

Region VII Mark Twain National Forest, Missouri

The herbicide 2,4,5-T was applied in 1977 to 3 sites totaling approximately 95 acres within the forest, to facilitate the relief of shortleaf pines from competing hardwoods. A tractor drawn, high-volume ground spray tanker unit was used to apply the herbicide.

A total of 50 soil samples were collected from 2 sub-areas at one of the 3 treated sites. These areas were located at the bottom of slopes, where herbicide runoff would tend to accumulate. Twenty-one of 50 soil samples contained 2,3,7,8-TCDD at levels between 0.3 and 120 ppt.

No additional action is planned at this time. The contamination is within a forest area, not used for grazing.

Region IX Tonto National Forest, Arizona

Between 1965 and 1969, 2,4,5-T, 2,4-D, and silvex were sprayed over more than 2,500 acres in the Globe Ranger District. This spraying project was designed to improve rangeland and to increase water runoff, resulting in increased water yields for downstream users.

Soil samples were collected from three helicopter landing areas used as herbicide mixing-loading areas and from five other locations within the sprayed area. Whole animals and animal tissues were also collected within the sprayed areas. Twenty-four of 77 soil samples had 2,3,7,8-TCDD at levels of 2 to 564 ppt. Soil contamination was found at two of the three mixing-loading areas. (The mixing-loading area where no 2,3,7,8-TCDD was found was later determined not to have been used for that purpose.) 2,3,7,8-TCDD was detected a short distance beyond the boundaries of the actual mixing/loading locations, but no 2,3,7,8-TCDD was detected at the other five locations. No 2,3,7,8-TCDD was detected in any of the animal samples.

Forty-five additional samples, which included soil and fish, were collected from 3 additional and 1 previously sampled mixing/loading area. Twenty-one soil samples contained 2,3,7,8-TCDD at levels from 0.4 to 6623 ppt. Four samples had levels greater than 1,000 ppt. No 2,3,7,8-TCDD was detected in the fish collected.

The U.S. Forest Service has restricted access to the contaminated heli-pads. EPA Region IX is reviewing alternative treatment technologies, focusing on in situ treatment. The Forest Service has indicated willingness to sponsor a pilot project.

Region IX Santa Ana River, California

The Santa Ana River Basin includes agricultural, industrial, and residential areas.

Twenty-eight sediment samples were collected from stations along the Santa Ana River and a few of its tributaries. These locations have been routinely monitored for conventional and priority pollutants. Fish samples were collected at eight of the sediment stations where water flow was sufficient to support fish. One sediment sample had 2,3,7,8-TCDD at 0.6 ppt; one of the seven whole fish had 2,3,7,8-TCDD at 4.6 ppt.

Region X Santiam Forest, Gates, Oregon

A 75-acre area of this forest site was aerially sprayed with a herbicide containing 2,4-D and 2,4,5-T in 1976 and 1977.

Twelve sediment samples were collected from a stream that runs through the sprayed area, from an area where this stream empties into the North Santiam River, and from an area of the North Santiam River near the confluence with the stream. Thirty-five soil samples were collected from a wetlands area south of the sprayed area, a heliport used by helicopters that sprayed the area, and the heliport drainage area. One fish sample was collected from the North Santiam River sampling area. 2,3,7,8-TCDD was detected in 3 of 12 sediment samples at levels of 0.2 and 0.4 ppt. No 2,3,7,8-TCDD was detected in the 35 soil samples analyzed or the 1 fish sample.

3.2.4 Findings

- Contamination was found at a variety of the pesticide use sites where 2,4,5-T, silvex, and 2,4,5-TCP based pesticides were used and in various media (soil, sediment, and fish); however, the levels found were generally very low.

- The highest levels for each media were generally found where sampling was targeted for specific areas most likely to be contaminated (areas used for equipment loading, areas where contaminants would tend to accumulate).
- Levels were much lower, in most cases not detected, for samples in areas where the pesticides were uniformly applied (spray areas).
- 2,3,7,8-TCDD was more frequently detected and was occasionally at higher levels at tier 5 sites than at background sites (tier 7).
- Two of the seven sites where fish were collected had detectable levels of 2,3,7,8-TCDD; whole fish were contaminated with levels up to 47 ppt (Petenwell Flowage).

3.2.5 Conclusions

- With the exception of helicopter loading areas in the Tonto National Forest, the levels found of tier 5 sites where spraying of pesticides occurred were generally low and of no concern. Further national investigation of tier 5 spray areas does not appear to be warranted.
- The source of 2,3,7,8-TCDD at the one significantly contaminated tier 5 site (Petenwell Flowage) may not be related to pesticide use. As described in greater detail under the tier 7 discussion, further investigations of certain types of pulp and paper mills using the chlorine bleaching process are being conducted.

3.3 Tier 6 - 'Other' Chemical Manufacturers

3.3.1 Objective

Tier 6 consists of organic chemical and pesticide manufacturing facilities where improper quality control on

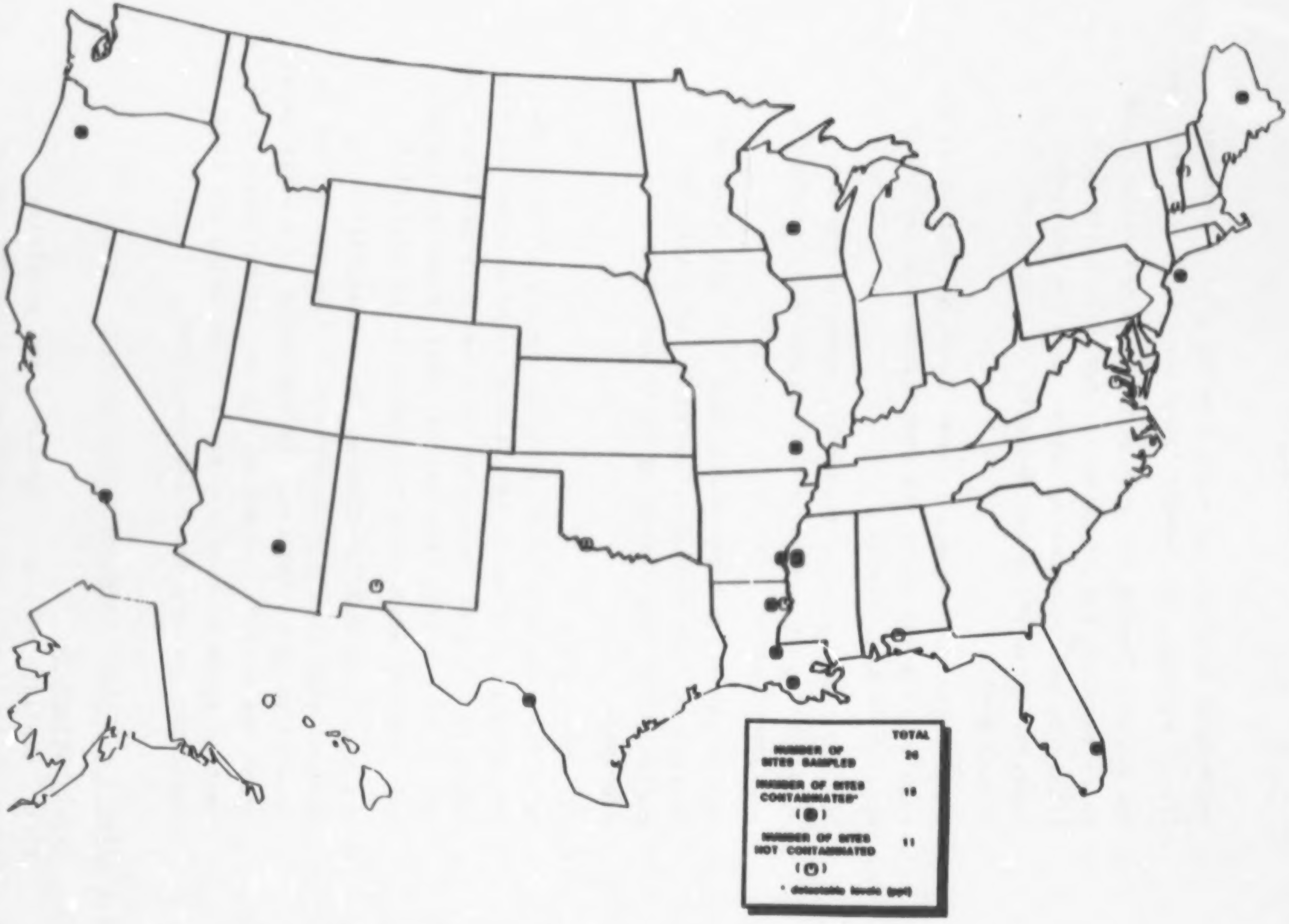

TOTAL
NUMBER OF SITES SAMPLED 26
NUMBER OF SITES CONTAMINATED* (●) 15
NUMBER OF SITES NOT CONTAMINATED (○) 11
* detectable levels (ppt)

FIGURE 3-3. LOCATIONS OF SAMPLED TIER 5 SITES

production processes could have caused products or waste streams to become contaminated with 2,3,7,8-TCDD. Facilities producing any of sixty compounds were identified. The objective of the sampling for this tier was to determine the percentage of facilities with concentrations of 2,3,7,8-TCDD above 1 ppb in soil or at detectable levels in other environmental media (e.g., fish in nearby streams).

3.3.2 Study Design

EPA identified 67 facilities which manufacture 1 or more of the 60 compounds of interest. Information to identify these facilities was obtained from the SRI Directory of Chemical Producers (1977-1983), FATES data base, Dioxins (EPA, 1980), and EPA Regional Office staff suggestions.

Twenty-five sites were statistically selected for sampling. EPA Regional Offices identified three additional facilities of particular interest, based on either known activities or previous contamination incidents at these facilities.

The approach to sampling tier 6 sites was identical to that described for tier 3. Of the 25 statistically selected sites, 10 were considered ineligible because further information revealed that no tier 6 compounds which could cause 2,3,7,8-TCDD to be formed were actually produced at these sites.

3.3.3 Results

Contamination (soil concentration greater than or equal to 1 ppb or detectable levels in other media) was found at 2 of the 15 statistically selected sampled sites and at 1 of the 3 regionally selected sites.

At all three contaminated sites, soil contamination was limited to one or two samples. At the regionally selected contaminated site, groundwater contamination was also found at the 0.07 to 0.10 ppt level in three samples. The groundwater at this site is not used as a drinking water source.

Soil concentrations below 1 ppb were detected at two additional statistically selected sites and at one additional regionally selected site.

Discussion of Contaminated Sites

Figure 3-4 and Table 3-4 summarize tier 6 results. Following is a narrative description of contaminated sites and sampling results. 2,3,7,8-TCDD was not detected at 12 of the 18 sites which were sampled. A summary of sampling at these sites is provided in the Tiers 3,5,6,7 Report.

Region II * W.A. Cleary - Somerset, New Jersey

This facility, located on 137 acres, produced mecoprop and 2,4-D salts from 1977 to 1983. During this time an estimated 10,000 gallons per year of liquid waste were discharged to an on-site lagoon.

Thirty-one soil samples were collected: 21 at the areas around the production buildings and the lagoon and 10 random samples from the remainder of the property which includes a densely wooded area and the company's golf course. One soil sample collected near a production building (below a loading dock) contained 2,3,7,8-TCDD at 34.7 ppb. 2,3,7,8-TCDD was not detected in a sediment sample collected from the lagoon.

This site has been referred to the Superfund program for further sampling.

Region VI * Chemall, Inc. (formerly Riverside Chemical Company) --Port Neches, Texas

This facility is located on 14.19 acres with the manufacturing facility situated on 11.9 fenced acres within the tract. A former operator of the facility produced pentachlorophenol (PCP) at this site prior to the facility's purchase by Chemall, Inc. in 1978. In addition, a number of organic chemicals, including 2,4,5-T (a tier 3 chemical) and 2,4-D and parathion (both tier 6 chemicals), have been stored at this site. As a result of a 1976 Texas Water Quality Board Enforcement Order, the former owner removed soils contaminated with PCP and toxaphene and covered areas around the processing facilities, warehouse, office and railroad spur with approximately one to two feet of crushed limestone.

Thirty-two soil samples were collected from drainage ditches, including those from the former PCP process and storage area, and from areas near unloading and storage areas. Many of these samples were taken from beneath pools of standing water; about

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* Denotes statistically selected site.

half were taken outside the fenced area. 2,3,7,8-TCDD was detected in nine samples, with two samples containing greater than 1 ppb (1.1 ppb & 1.4 ppb). These two samples were collected from the tank car unloading area and the drainage ditches from behind the central warehouse, where 2,4,5-T, 2,4-D, parathion and other chemicals were stored. The runoff area from the former PCP process and storage area contained 2,3,7,8-TCDD at levels below 1 ppb.

The Texas Water Commission (TWC) currently has Chemall under an enforcement action to undertake remedial action relating to contamination found on-site and in adjacent ditches. All areas where 2,3,7,8-TCDD was detected will be addressed in the TWC's enforcement action. The TWC will coordinate with EPA Region VI to assure compliance with EPA's dioxin regulations.

Region IX BMI Complex - Henderson, Nevada

This industrial complex covers more than 350 acres and includes the Stauffer Chemical Company and the Montrose Chemical Corporation.

The Stauffer facility produced lindane from 1948 to 1956, ethyl and methyl parathion intermittently since 1958, and carbophenothion. Alpha and beta BHC were produced as waste products from the production of lindane. The waste BHC was disposed of in a surface pile, which was capped with a 1-foot layer of clay in 1978-1979. Prior to 1974, aqueous wastes from the production of carbophenothion were disposed of in on-site leach beds, and drums containing still bottoms from the carbophenothion process were buried on-site. Both areas have been capped with a 1-foot clay layer. After 1974, carbophenothion wastes were disposed of in on-site lined ponds or in an off-site landfill.

Montrose Chemical produced chlorobenzenes at this site from 1947 to 1983. From 1947 to 1976, polychlorinated benzene wastes (still bottoms) were disposed of in the on-site BMI dump. From 1976 to 1983, the polychlorinated benzene wastes were disposed of in a lined pond. In 1980, the still bottoms from this pond were transferred to a storage tank.

Thirty-seven soil samples were collected from chemical production, storage and loading areas, associated drainage areas, and from areas adjacent to former waste disposal locations. 2,3,7,8-TCDD was detected at 1 ppb in one soil sample, taken down-gradient from the chlorobenzene still bottom disposal area. Seven ground water samples were also collected from Stauffer's ground-water intercept and treatment system. 2,3,7,8-TCDD was detected in four of these samples, at levels ranging from 0.07 to 0.11 ppt. Other dioxin isomers were also detected but not quantified.

Montrose Chemical's use of caustic soda in its former production of chlorobenzene may account for the levels of 2,3,7,8-TCDD. (Chlorobenzenes were not included as tier 6 compounds because it was not suspected that 2,3,7,8-TCDD could be formed during their manufacture.) The 2,3,7,8-TCDD detected in groundwater may have been brought into solution by benzene and chlorobenzenes disposed of on-site.

Additional soil, water, and waste samples have been collected. Analysis of these samples has been delayed until the resolution of analytical difficulties (complex mixtures of chlorinated products).

3.3.4 Findings

- EPA estimates that 9 percent of the 67 facilities originally identified as tier 6 sites would be found to be contaminated.
- None of the three contaminated sites were extensively contaminated with 2,3,7,8-TCDD.

3.3.5 Conclusion

- Further national investigation of tier 6 sites for 2,3,7,8-TCDD does not appear to be warranted.

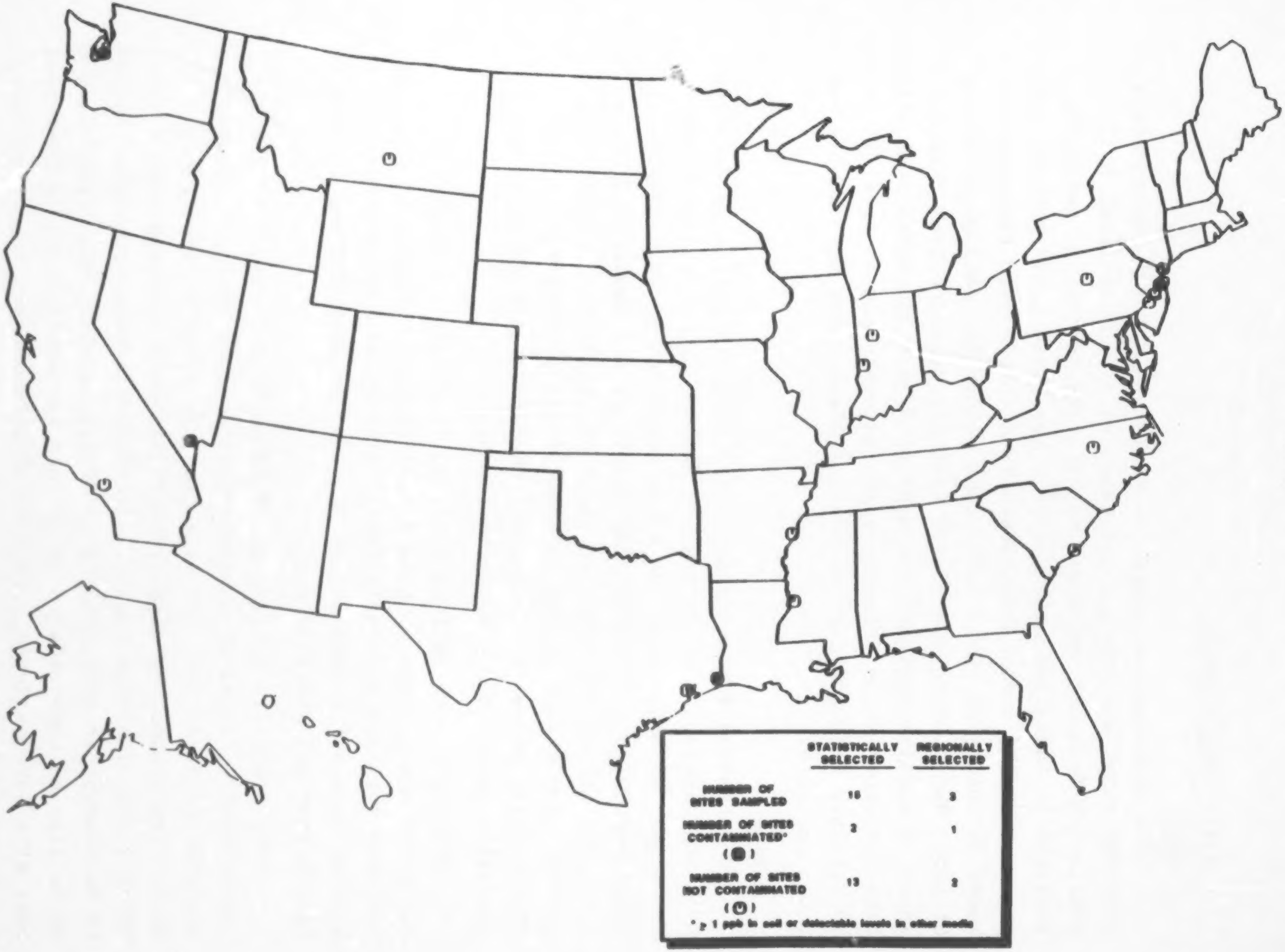
3.4 Tier 7 - Background Sites

3.4.1 Objectives

Tier 7 consists of sites that did not have previously known sources of 2,3,7,8-TCDD contamination. The tier 7 investigation was intended to establish the prevalence of 2,3,7,8-TCDD in the environment and to provide a basis for comparison with results from the other tiers. The specific objectives of the sampling were to:

- Determine the percentage of sites in the EPA Urban and Rural Soil Networks that have detectable levels of 2,3,7,8-TCDD in soil at a detection limit of approximately 1 ppt.
- Determine the percentage of sites in the combined U.S. Geological Survey's (USGS) National Stream Quality Accounting Network (NASQAN) and Benchmark Network that have detectable levels of 2,3,7,8-TCDD in fish tissue at a detection limit of approximately 1 ppt.

EPA Regional Offices also selected a large number of additional fish samples in areas of general interest, including areas near population centers, recreational or commercial fishing areas or historical sampling areas.



	STATISTICALLY SELECTED	REGIONALLY SELECTED
NUMBER OF SITES SAMPLED	15	3
NUMBER OF SITES CONTAMINATED* (●)	2	1
NUMBER OF SITES NOT CONTAMINATED (○)	13	2

* ≥ 1 ppb in soil or detectable levels in other media

FIGURE 3-4. LOCATIONS OF SAMPLED TIER 6 SITES

3.4.2 Study Design

Soil

Soil sampling locations (both urban and rural) were chosen from the Rural and Urban Soils Networks of the National Soils Monitoring Program, which was established to monitor pesticide residues in rural and urban soils. The Rural Soils Network consists of 13,280 rural sites identified in the 1967 Conservation Needs Inventory of rural land areas within the contiguous United States. Two-hundred sites were randomly selected from this network. A similar approach was used to select 300 urban soil sites from the Urban Soils Network, which is comprised of 1,761 sites in 20 Standard Metropolitan Statistical Areas. One soil sample was taken per site.

Fish

One-hundred fish sampling sites were statistically selected from the combined U.S. Geological Survey NASQAN and Benchmark Networks. An additional 305 sites suggested by EPA's Office of Water Regulations and Standards (OWRS) or EPA Regional Offices were also chosen for sampling based on proximity to population centers, commercial or recreational fishing activity, or availability of water quality information. Fish sampling was generally conducted by State personnel.

Protocols were defined to limit fish sample collection variables among sites. Certain species were targeted in order to minimize interspecies variations. Fish of similar age were sampled whenever possible, and the time of sampling was limited to reduce seasonal variations.

Four composite samples per site were collected: 1) a whole bottom-feeding fish, 2) a bottom-feeding fish filet, 3) a whole predator or game fish, and 4) a predator or game fish filet. Whole fish composites of bottom-feeders were analyzed first because data indicate that 2,3,7,8-TCDD concentrations are likely to be highest in these samples. If 2,3,7,8-TCDD was detected in a whole fish bottom-feeder sample, then the other three samples from that site were analyzed. Because of differences in species, age, or fat content of the fish being composited for each separate analysis, it is possible that the highest level found at a site could be in a sample other than the whole bottom-feeding fish.

3.4.3 Results

Of the statistically selected soil sites, 141 of 200 rural and 221 of 300 urban sites were sampled. The remaining 59 rural sites and 79 urban sites could not be sampled because of difficulty in locating the site (131 sites) or because permission to collect a sample was denied (7 sites). Of the 100 statistically selected fish sites, 90 were sampled. The remaining 10 sites could not be sampled because of lack of water, fish, or success in catching the latter.

Soil

Seventeen of the 221 urban soil sites and one of the 138 rural sites had detectable levels of 2,3,7,8-TCDD; the levels were very low--between 0.2 and 11.2 ppt. (The Linn County Oregon rural soil sample had 0.5 ppt). Samples for three sites were not analyzed because they were either lost or broken during shipment.

Fish

Fish from 17 of the 90 statistically selected sites had detectable levels up to 19 ppt in the whole fish composite sample.

Whole fish composite samples from 95 of the 305 regionally selected sites (includes rivers, Great Lakes, and estuarine and coastal sites) (31 percent) had detectable levels up to 85 ppt. This frequency is greater than that found for the statistically selected sites; however, many of the regionally selected sites were near urban or industrialized areas.

Only 4 of the 57 estuarine or coastal sites had detectable levels in fish or shellfish, with concentrations ranging from 1.08 to 3.5 ppt. Three of the four sites with detectable levels were in heavily industrialized areas, while the fourth contaminated sample was collected from weathered, chemically-treated wood pilings. Additional analyses of shellfish attached to recent, chemically-treated wood pilings and artificial substrate at this site showed no detectable 2,3,7,8-TCDD.

At 74 sites (67 percent) where 2,3,7,8-TCDD was detected, the maximum value was below 5 ppt, while at 4 sites levels were above 25 ppt. As a result of these findings, two advisories to limit fish consumption have been issued by the States of Maine (for the Androscoggin River at Lewiston) and Minnesota (for the Rainy River at International Falls). An advisory was already in effect for fish caught in Lake Ontario due to contamination from mirex, PCBs, and mercury. Additional sampling will be conducted at the fourth site (Flint River at Elms Road) to verify levels and identify potential sources of 2,3,7,8-TCDD.

Twenty-three of the 29 sampled sites in the Great Lakes were found to have detectable levels of 2,3,7,8-TCDD, which is a much higher proportion than in the statistically selected or other regionally selected sites. Possible explanations for this finding include: 1) the sites were selected based on potential contamination from prior evaluation of toxic pollutants; 2) the long water retention of the lakes causes elevated pollutant levels in the system; and 3) there are many sources of pollutants entering the lakes. Areas in the lakes with higher levels are subjects of State fish advisories, based on other chemicals. Further investigation is being conducted cooperatively by Regional Offices, States, and the Great Lakes National Program Office.

Outside of the Great Lakes, detectable levels in fish appear to be most frequently found in major river systems such as the Ohio and Mississippi Rivers, or in waterways with significant industrial activity.

Levels found in filet samples (between 0.4-41 ppt) were generally lower than levels in the whole fish samples. In 46 percent of the cases where 2,3,7,8-TCDD was detected in whole fish, it was not detected in the filet sample. Even though only one filet sample was greater than the FDA advisory level of 25 ppt, the levels found in fish filets may be a cause for concern under particular conditions at specific locations. For example, using the EPA cancer model and the consumption estimates from EPA's water quality criteria document, fish contaminated at the detection level of approximately 1 ppt could cause an increased lifetime cancer risk of 1 in 100,000. The results from tier 7 should be carefully evaluated by local, State, and Federal agencies in light of local exposure conditions in determining appropriate levels of concern. Site-specific factors include consumption patterns (type of fish and amount consumed), length of exposure, level of contamination, and percent of fish contaminated.

EPA used two approaches in an effort to determine possible associations between 2,3,7,8-TCDD presence in fish and various sources: 1) preparing stream profiles identifying types of industrial dischargers in the vicinity of the fish sampling sites, and 2) conducting additional sampling at selected sites.

The two sites with the highest 2,3,7,8-TCDD levels in whole fish (the Androscoggin River--maximum 29 ppt, and the Rainy River--maximum 85 ppt) have upstream pulp and paper mill discharges. Elevated levels in fish were also found below paper mills in the Petenwell Flowage. Further investigations at those sites have included sampling of waste treatment sludges from the mills. Levels of up to 414 ppt have been found in these sludge samples. Additional investigations, including those previously described for the Petenwell Flowage (tier 5) site, are underway by EPA, States, and the paper industry to determine the sources of 2,3,7,8-TCDD within several mills that produce bleached pulp using chlorine-based chemicals.

3.4.4 Findings

Figures 3-5 and 3-6 and Tables 3-5 through 3-9 provide a summary of tier 7 results.

Soil

- o 2,3,7,8-TCDD was detected infrequently and at very low levels in background soil samples. Seventeen of 221 urban sites and 1 of 138 rural sites had detectable levels, with the highest level found being 11.2 ppt in an urban soil sample.

Fish

- EPA estimates that 21 percent of the U.S. Geological Survey national monitoring network sites would have detectable levels above 1 ppt in fish. The frequency of detection is greater (31 percent) at sites selected by EPA's Regional Offices, many of which are near industrial and urban areas.
- An even higher proportion (23 of 29) of Great Lakes fish sampling sites had detectable levels. This is of concern as it suggests multiple sources to the Great Lakes, which, because of their long water retention times, have increased bioaccumulation potential.

3.4.5 Conclusions

- 2,3,7,8-TCDD levels in filet samples can be a cause for concern at specific locations under certain consumption patterns; local exposure conditions must be evaluated to determine levels of concern for those areas.
- Fish and shellfish from estuarine and coastal waters were rarely contaminated; three of the four sites where 2,3,7,8-TCDD was detected are in areas heavily influenced by industrial discharges.
- A previously unsuspected possible source of contamination in some areas appears to be certain types of pulp and paper mill discharges. Mills using a chlorine bleaching process are being investigated by EPA, States and the paper industry to determine the source of 2,3,7,8-TCDD within the mills.
- Fish contamination is a current and continuing phenomenon since recent EPA studies indicate that 2,3,7,8-TCDD has a half-life of slightly less than 1 year in fish.

- Based on the very small number of positive soil samples and the low levels detected, soil contamination does not appear to be a problem in either rural or urban background settings.
- 2,3,7,8-TCDD contamination in fish may be a cause for concern in specific locations. Site-specific factors including levels of contamination, types of fish, length of exposure, and levels of consumption must be evaluated to determine the appropriate level of concern and response.

3.5 Follow-on Investigations

Pulp and Paper Mills

As previously discussed, results from the study indicate that 2,3,7,8-TCDD is present in fish and river sediments downstream from a number of pulp and paper mills located in various parts of the country. In addition, current wastewater treatment plant sludges from some Maine, Minnesota, and Wisconsin mills are contaminated with 2,3,7,8-TCDD and other CDDs and CDFs.

Given current knowledge and concerns about protection of fisheries, EPA and the paper industry have initiated a cooperative sampling program. Data will be used to assess conditions at sampled mills using chlorine bleaching processes, to draw preliminary conclusions about the presence of dioxin in pulp and paper processes in general, and to help focus further regulatory work in this area.

Sludges, process materials, and water and waste waters will be analyzed for 2,3,7,8-TCDD, 2,3,7,8-TCDF, and other CDDS and CDFs as homologues. Isomer-specific analyses for 2,3,7,8-substituted congeners and certain other selected congeners will be conducted on selected samples. Detection levels in the low parts per trillion (ppt) range are required for sludges and process materials and in the low parts per quadrillion (ppq) range for water and wastewaters. Analyses for a number of other related compounds potentially associated with paper making operations will

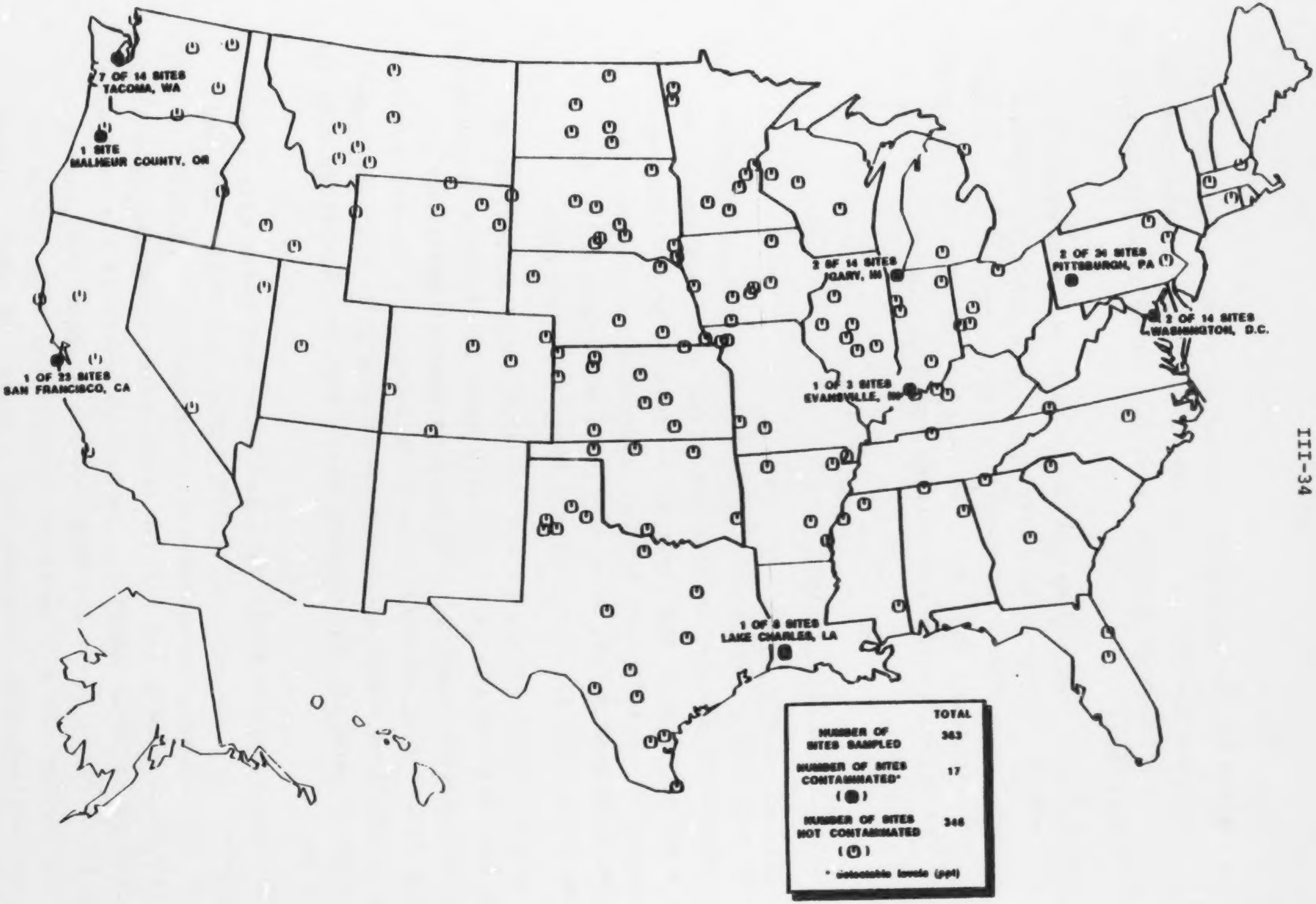

7 OF 14 SITES
TACOMA, WA
1 SITE
MALHEUR COUNTY, OR
1 OF 23 SITES
SAN FRANCISCO, CA
2 OF 14 SITES
GARY, IN
1 OF 3 SITES
EVANSVILLE, IN
2 OF 24 SITES
PITTSBURGH, PA
2 OF 14 SITES
WASHINGTON, D.C.
1 OF 8 SITES
LAKE CHARLES, LA
TOTAL
NUMBER OF SITES SAMPLED 363
NUMBER OF SITES CONTAMINATED* (●) 17
NUMBER OF SITES NOT CONTAMINATED (Ⓤ) 346
* detectable levels (ppt)

FIGURE 3-5. LOCATIONS OF SAMPLED TIER 7 SOIL SITES

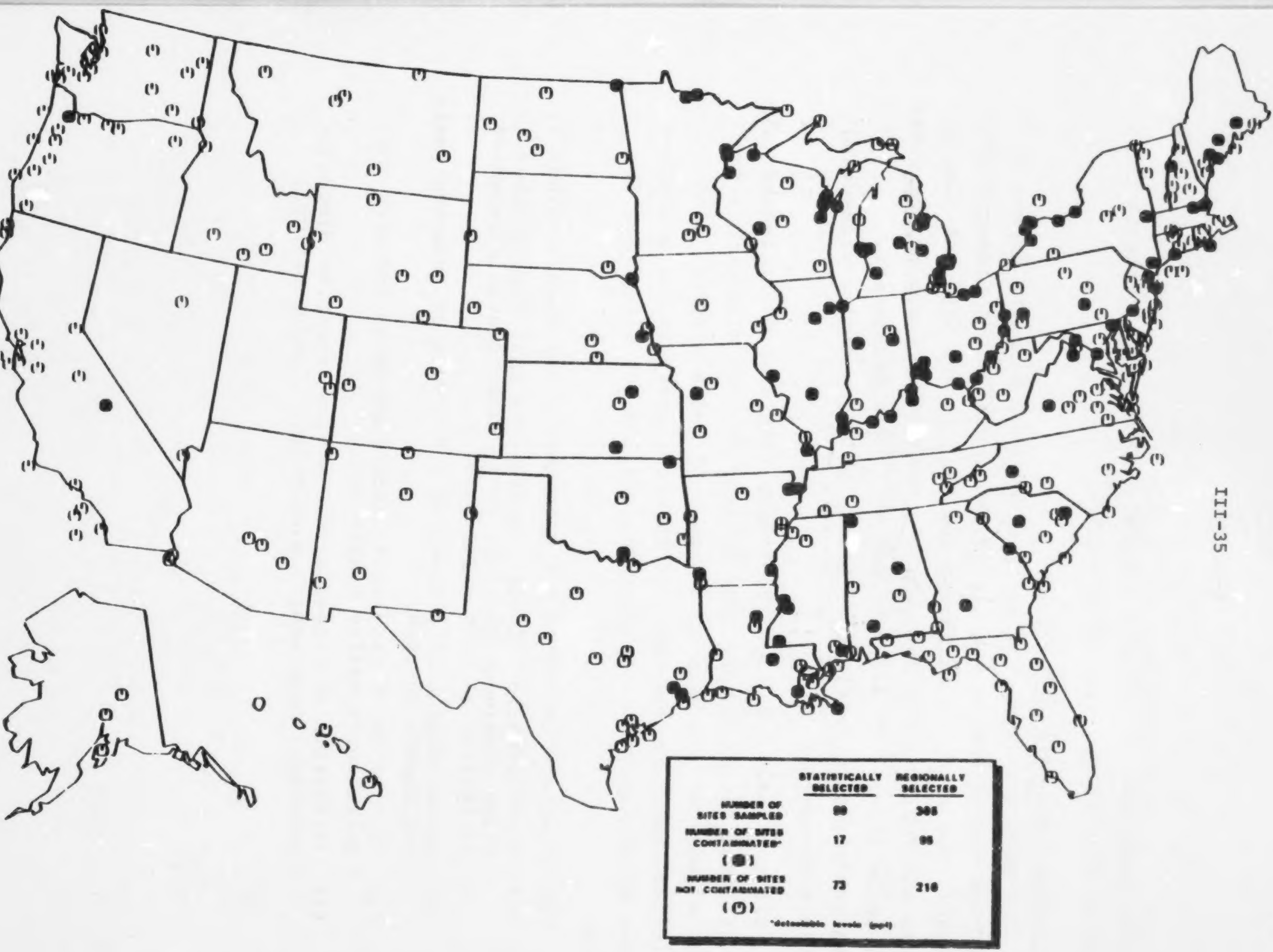

STATISTICALLY SELECTED
REGIONALLY SELECTED
NUMBER OF SITES SAMPLED
90
306
NUMBER OF SITES CONTAMINATED*
(●)
17
96
NUMBER OF SITES NOT CONTAMINATED
(⊖)
73
210
*detectable levels (ppt)

FIGURE 3-6. LOCATIONS OF SAMPLED TIER 7 FISH AND SHELLFISH SITES

also be performed on selected samples. Detection limits in the range of 1 to 10 ppb will be required.

Bioaccumulative Pollutant Study

The bioaccumulation study is a national sampling survey to determine the extent to which selected contaminants bioaccumulate in fish. The study is in part a followup to the National Dioxin Study, and reflects EPA and public concern that there may be other pollutants similar to 2,3,7,8-TCDD which are persistent, bioaccumulative, significantly toxic, and potentially widespread in the environment.

EPA currently has over 400 frozen fish samples collected from the National Dioxin Study. The funding for the bioaccumulation study allows for analysis of a subset of these samples, plus additional sampling and specific chemical analysis for a limited number of contaminants at approximately 250 new sites over 2 years.

The objective and potential outcomes of the study include:

(1) identification of toxic pollutants that need further study (toxicity testing, monitoring, source assessment, analytical methods development);

(2) establishment of a baseline for levels of selected toxic pollutants in fish;

(3) initiation of regulatory decisions on an industry- or pollutant-specific basis; and

(4) initiation of site-specific action (stricter discharge permits, local health advisories, cleanup action).

TABLE 3-1. ANALYTICAL RESULTS FOR CONTAMINATED TIER 3 SITES--STATISTICALLY SELECTED SITES

REGION		LOCATION	DESCRIPTION:	MATRIX TYPE	# SAMPLED	# DETECTED	RANGE (PPB UNLESS OTHERWISE NOTED)	# CONT[a]	DET LIMIT (PPB UNLESS OTHERWISE NOTED)
CONTAMINATED[a] SITES:									
2	NY	FARMINGDALE	FARMINGDALE GARDEN LABS, INC.	SOIL	25	1	17.6	1	0.1 - 0.94
	NJ	W. CALDWELL	ROCKLAND CHEM. CO.	SOIL	10	1	1.3	1	0.03 - 1.1
3	WV	ONA	HOLDER CORP.	SOIL	36	0	ND	0	0.012 - 0.84
				SEDIMENT	5	0	ND	0	0.72 - 8 (PPT)
				FISH	3	3	0.5 - 2.9 (PPT)	3	0.05 - 0.3 (PPT)
				CLAM	1	0	ND	0	2.2 (PPT)
4	GA	FORT VALLEY	SECURITY CHEM. CO. (WOOLFOLK CHEM.)						
				SOIL	16	2	23 - 40	2	0.13 - 21
				SOIL	1	1	36.7 (PPT)	0	NA
5	IL	CHICAGO HEIGHTS	RIVERDALE CHEM. CO.	SOIL	14	14	1.1 - 364	13	NA
	MI	GRAND LEDGE	ETM ENTERPRISES	SOIL	21	2	0.56 - 1.13	1	0.05 - 0.76

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[a] Contamination defined as concentration greater than or equal to 1 ppb in soil or above detectable levels in other media.

ANALYTICAL RESULTS FOR CONTAMINATED TIER 3 SITES--REGIONALLY SELECTED SITES

REGION LOCATION DESCRIPTION:				MATRIX TYPE	# SAMPLED	# DETECTED	RANGE (PPB UNLESS OTHERWISE NOTED)	# CONT[a]	DET LIMIT (PPB UNLESS OTHERWISE NOTED)
CONTAMINATED[a] SITES:									
3	VA	ALEXANDRIA	R.H. BOGLE CO.	SOIL	40	0	ND	0	0.07 - 0.89
				FISH-WHOLE	4	4	1.6 - 6.3 (PPT)	4	0.3 - 1.3 (PPT)
				FISH-FILET	4	3	1.9 - 5.0 (PPT)	3	0.4 - 1.3 (PPT)
				SEDIMENT	9	5	5.5 - 23 (PPT)	5	1.2 - 9.7 (PPT)
	VA	NORFOLK	SMITH DOUGLAS CO. (BORDEN)	SOIL	53	1	10.1	1	0.01 - 0.83
				DUST	10	0	ND	0	0.08 - 0.83
				OTHER	1	0	ND	0	0.12
4	FL	BELLE GLADE	CHEM. SPRAY, INC.	SOIL	19	2	0.2 - 3.0	1	0.01 - 60
				SEDIMENT	7	7	20.9 - 515 (PPT)	7	NA
5	IL	BEDFORD PARK	NALCO CHEM. CO.	SOIL	10	2	1.9 - 2.2	2	0.76 - 0.65
7	MD	SAINT JOSEPH	UNION CARBIDE	SOIL	26	23	0.13 - 39.1	16	0.11 - 1.04
9	CA	SANTE FE SPRINGS	MAGNA CORP.	SOIL	10	1	2.0	1	0.07 - 0.7

TABLE 3-2. ANALYTICAL RESULTS FOR CONTAMINATED TIER 5 SITES

REGION LOCATION DESCRIPTION:	MATRIX TYPE	# SAMPLED	# DETECTED	RANGE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES:					
1 ME B&A - R-O-W - GRINDSTONE					
	SOIL	22	18	8 - 35	1 - 68
2 NY LONG ISLAND RAILROAD - STEWART MANOR					
	SOIL	26	1	9	1 - 44
4 FL WEST PALM BEACH - FLORIDA CANALS					
	SEDIMENT	36	27	0.7 - 26.5	0.12 - 1.35
4 MS CLEVELAND CO.					
	SOIL	20	16	0.8 - 1.7	0.42 - 1.21
4 MS SCOT CO.					
	RICE	1	0	ND	0.6
	SOIL	20	2	0.6 - 0.7	0.22 - 1.45
5 WI PETENWELL FLOWAGE - WISCONSIN RIVER					
	BOTTOM FEEDER-FILET	3	3	20 - 23	0.5 - 1.6
	BOTTOM FEEDER-WHOLE	4	4	25 - 47	0.7 - 1.2
	GREAT BLUE HERON	3	1	1.2	0.12 - 0.2
	GREEN HERON	1	1	0.76	0.4
	KING FISHER	2	2	7.8 - 12	0.4 - 0.7
	RACCOON FAT	3	1	1.9	0.13 - 0.4
	PREDATOR-FILET	2	2	3 - 8	0.8 - 0.9
	PREDATOR-WHOLE	2	2	9 - 37	0.5 - 0.7
6 AR DESHA CO.					
	PLANT TISSUE	5	0	ND	1 - 10
	SEDIMENT	3	0	ND	1 - 2
	SOIL	46	1	3	1 - 8
6 LA ASSUMPTION PARISH					
	SOIL	24	14	0.3 - 1.1	0.28 - 0.82

---

[a] Contamination defined as detectable levels

TABLE 3-2. (CONT.)

REGION LOCATION DESCRIPTION:	MATRIX TYPE	# SAMPLED	# DETECTED	RANGE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES:					
6 LA POINT COUPEE PARISH	SOIL	25	20	1 - 2.5	0.26 - 1.15
6 LA RICHLAND PARISH	SEDIMENT	1	0	ND	0.46
	SOIL	35	9	0.3 - 0.4	0.19 - 0.39
6 TX RIO GRANDE PLAIN EXP. RANCH - KINNEY COUNTY	SOIL	38	12	0.2 - 3	0.09 - 0.75
	RATTLESNAKE	1	0	ND	0.1
	VEGETATION	6	0	ND	0.5 - 1.1
7 MO MARK TWAIN NATIONAL FOREST - FREDERICTOWN	SOIL	50	21	0.3 - 124	0.17 - 0.7
9 AZ TONTO NATIONAL FOREST	SOIL	121	45	1.1 - 6623	0.06 - 33
	COYOTE FAT	1	0	ND	5.1
	COYOTE KIDNEY	1	0	ND	0.6
	COYOTE LIVER	1	0	ND	0.8
	DEER FAT	2	0	ND	5 - 6.9
	DEER KIDNEY	1	0	ND	0.2
	DEER LIVER	3	0	ND	0.3 - 0.6
	FROGS WHOLE (20)	1	0	ND	0.3
	JAVELINA FAT	3	0	ND	3 - 11
	JAVELINA KIDNEY	2	0	ND	0.2 - 0.4
	JAVELINA LIVER	3	0	ND	0.4 - 0.8
	QUAIL WHOLE	1	0	ND	0.3
	SUNFISH WHOLE	1	0	ND	0.44
	SNAKE WHOLE	3	0	ND	0.3 - 1.7
	TOAD WHOLE	1	0	ND	0.5

TABLE 3-2. (CONT.)

REGION LOCATION DESCRIPTION:	MATRIX TYPE	# SAMPLED	# DETECTED	RANGE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES:					
9 CA SANTA ANA RIVER					
	BOTTOM FEEDER-WHOLE	7	1	4.6	0.24 - 0.68
	PREDATOR-WHOLE	2	0	ND	0.05 - 0.67
	SEDIMENT	28	1	0.6	0.14 - 0.85
10 OR SANTIAM FOREST - GATES					
	SEDIMENT	12	3	0.2 - 0.4	0.1 - 0.43
	SOIL	35	0	ND	0.13 - 1.05
	WHOLE SCULPIN	1	0	ND	0.3

---

[a] Contamination defined as detectable levels.

TABLE 3-3
TIER 5 SITE CHARACTERIZATION

Region	Name of Site	Site Use	Pesticide Applied	Date(s) Treated	Volume Applied	Area Applied	Rate of Application(AI)	Type of Application
I	Lake Abenaki, VT	Aquatic recreation and private water supply	Silvex	1975	5 gal. Silvex	15 acres (southern third)	1/3 gal/acre (calculated)	Spraying from boat
	Lake Clara, VT	Aquatic recreation	Silvex	1971-73 (once each year)	5 gal. (1973)	18 acres (1972)[2]; spot treatment (1973)	Unknown	Spraying from boat
	Grindstone, ME	Railroad right-of-way	2,4,5-T[3]	? - 1977	537.5 lbs.	1075 acres (along railroad)	0.5 lbs/acre	Spray
	Yarmouth, ME	Powerline right-of-way	2,4,5-T	1978	Unknown	Within 75 ft of tower centerline	Unknown	Sprayed at base of selected plant
II	Long Island Railroad, NY	Right-of-way	2,4,5-TCP herbicides	1970's	Unknown	Area unknown (along railroad)	Unknown	Spray
III	King & Queen Co., VA	Forest	2,4,5-T	?-1978	300 lbs/yr (calculated)	150 acres	2 lbs/acre	Unknown; probably spray
	Matthews Co., VA	Forest	2,4,5-T with 2,4-D	?-1978	40 lbs/yr (calculated)	20 acres	2 lbs/acre	Unknown; probably spray
IV	Cleveland, MS	Ricefield	2,4,5-T	1978, 1981, 1984	Unknown	Unknown	1 qt/acre	Unknown
	Boyle, MS	Ricefield	No information available	Unknown	Unknown	Unknown	Unknown	Unknown

TABLE 3-3
TIER 5 SITE CHARACTERIZATION

Region	Name of Site	Site Use	Pesticide Applied	Date(s) Treated	Volume Applied	Area Applied	Rate of Application(AI)	Type of Application
IV (cont.)	Scot, MS	Ricefield	2,4,5-T	1984	Unknown	Unknown	Unknown	Unknown
	West Palm Beach, FL	Sugarcane Field	Silvex	Unknown	Unknown	Unknown	Unknown	Unknown
	Escambia Exp. Brewton, AL	Forest	2,4,5-T	1957	Unknown	Unknown	Unknown	Aerial spray
V	Petenwell Flowage, WI	Carp Fishery; closed since 1983	Trichlorophenate	? - 1980	9,000 lbs	Pulp and Paper mills upstream	Unknown	Paper mill biocide
VI	Assumption Parish, LA	Sugarcane	Silvex	1982	Unknown	8.1 acres	2 lbs/acre	Spray from ground rig
	Pointe Coupee Parish, LA	Sugarcane field (soybeans in 1985)	Silvex	1983	Unknown	2 fields, 2.6 acres and 2.7 acres	2 lbs/acre	Spray from ground rig
	U. of Arkansas Experimental Station Desha County, AR	Ricefield (soybean in rotation)	2,4,5-T	1972, 1974 1975	15 lbs each field (calculated)	2 fields, 20 acres each	0.75 lbs/acre	Aerial spray
	New Mexico State Univ. Expt. Ranch Dona Ana Cty, NM	Rangeland	2,4,5-T Silvex	1968 1984	400 lbs Unknown	800 acres 4000 acres	0.5 lbs/acre Unknown	Aerial spray Aerial spray
	Madison Parish, LA	Ricefield	2,4,5-T	1982, 1983	25 gal (1982); 17.5 gal (1983) (calculated)	200 acres (1982) 140 acres (1983)	1/8 gal/acre	Aerial spray
	Rio Grande Plain Experimental Ranch, Kinney Co, TX	Rangeland	2,4,5-T	1981	2.5 lbs	Experimental application-3 plots approx. 5 acres	0.5 lb/acre	Aerial spray

TABLE 3-3
TIER 5 SITE CHARACTERIZATION

Region	Name of Site	Site Use	Pesticide Applied	Date(s) Treated	Volume Applied	Area Applied	Rate of Application(AI)	Type of Application
vI (cont.)	Oklahoma Rangeland Site 1, Tillman Co., OK	Rangeland	2,4,5-T	1980, 1984	93 lbs	93 acres	1 lb/acre	Aerial spray
	Richland Parish, LA	Ricefield	2,4,5-T	1982 (once); 1983 (twice)	22 gal. total (calculated)	40 acres (1982); 65 and 72 acres (1983)	1/8 gal/acre	Aerial spray
VII	Mark Twain National Forest, MO	Forest	2,4,5-T	1977	190 lbs (est.)	3 sites, 95 acres total[4]	2 lbs acid equiv/acre	Ground spray
IX	Tonto National Forest, AZ	Forest	2,4,5-T; 2,4-D Silvex	1965-1966; 1968-1969[5]	5400 lbs 2,4-D and 2,4,5-T; 7260 lbs silvex	Greater than 2560 acres	2 lbs acid equiv./acre	Aerial spray
	North California Rice Growing Areas	Ricefield	2,4,5-T and Silvex	Before 1971 thru 1982	Unknown	Unknown[6]	Unknown	Spray
	Santa Ana River, CA	Multiple uses	No information available	Unknown	Unknown	Unknown	Unknown	Unknown
X	Santiam State Forest, Gates, OR	Forest	2,4,5-T and 2,4-D	1976-1977	Unknown	75 acres	2 lbs acid equiv./acre	Spray

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[1] Max. depth of lake: 7 ft.

[2] Lake was partially drained in 1982; now about 1/3 the size of original lake: 4-5 ft deep.

[3] Area was sprayed with several pesticides (including 2,4,5-T in 1977) from 1975 to 1983.

[4] Sampled areas include portion of the site where 2,4,5-T was sprayed and where surface runoff from the sprayed sites would drain.

[5] Initial spraying in 1965 and 1966; maintenance spraying in 1968 and 1969.

[6] Conflicting data exist; info. from pesticide use permits probably includes rangeland; sampled area represents points where runoff from ricefields could impact river water quality.

TABLE 3-4. ANALYTICAL RESULTS FOR CONTAMINATED TIER 6 SITES--STATISTICALLY SELECTED SITES

REGION LOCATION DESCRIPTION:				MATRIX TYPE	# SAMPLED	# DETECTED	RANGE (PPB UNLESS OTHERWISE NOTED)	# CONT[a]	DET LIMIT (PPB UNLESS OTHERWISE NOTED)
CONTAMINATED[a] SITES:									
2	NJ	SOMERSET	W.A. CLEARY	SOIL	31	1	34.7^{b}	1	0.02 - 0.17
				SEDIMENT	1	0	ND	0	0.08
6	TX	PORT NECHES	CHEM ALL, INC. (RIVERSIDE CHEMICALS)	SOIL	32	9	0.1 - 1.4	2	0.028 - 0.37

- REGIONALLY SELECTED SITES

REGION LOCATION DESCRIPTION:				MATRIX TYPE	# SAMPLED	# DETECTED	RANGE (PPB UNLESS OTHERWISE NOTED)	# CONT[a]	DET LIMIT (PPB UNLESS OTHERWISE NOTED)
CONTAMINATED[a] SITES:									
9	NV	HENDERSON	STAUFFER CHEM.	SOIL	37	1	1	1	0.05 - 0.29
				WATER	7	4	0.07 - 0.11 (PPT)	4	0.005 - 0.02 (PPT)
				AQUEOUS LIQUID	4	0	ND	0	0.002 - 0.005

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[a] Contamination defined as concentration greater than 1 ppb in soil or detectable levels in other media

[b] Concentration level uncertain - may be high by 20%

TABLE 3-5. RESULTS OF ANALYSES OF TIER 7 URBAN SOILS

REGION	LOCATION DESCRIPTION[a]:	NO. SAMPLES	DETECTION LIMIT (PPT)	LEVELS DETECTED (PPT)
CONTAMINATED[b] LOCATIONS :				
3	DC, WASHINGTON	3	0.40 - 2.0	3.0 2.0 4.0
	PA, PITTSBURGH	2	1.0 - 4.0	5.0 2.0
5	IN, EVANSVILLE	1	NOT AVAILABLE	1.3
	IN, GARY	2	NOT AVAILABLE	0.5 4.1
	LA, LAKE CHARLES	1	NOT AVAILABLE	0.2
9	CA, SAN FRANCISCO	1	1.0	2.0
10	WA, TACOMA	7	NOT AVAILABLE	0.4 0.5 0.6 0.8 1.9 8.7 11.2
	TOTAL	17		
NOT DETECTED LOCATIONS:				
1	CT, HARTFORD	8	1.0 - 10.0	ND
	MA, FITCHBURG	6	1.0 - 10.0	ND
	MA, PITTSFIELD	9	1.0 - 4.0	ND
3	PA, PITTSBURGH	22	1.0 - 9.0	ND
	PA, READING	7	1.0 - 4.0	ND
	VA, NEWPORT NEWS	11	1.0 - 4.0	ND
	DC, WASHINGTON	16	0.4 - 17.0	ND

TABLE 3-5. RESULTS OF ANALYSES OF TIER 7 URBAN SOILS

REGION	LOCATION DESCRIPTION[a]:	NO. SAMPLES	DETECTION LIMIT (PPT)	LEVELS DETECTED (PPT)
NOT DETECTED LOCATIONS				
4	AL, GADSDEN	8	1.0 - 3.0	ND
	GA, MACON	7	1.0 - 2.0	ND
	NC, DURHAM	12	0.5 - 5.5	ND
	SC, GREENVILLE	7	0.7 - 1.8	ND
5	IL, SPRINGFIELD	11	1.0 - 9.0	ND
	IN, EVANSVILLE	2	0.2 - 0.34	ND
	IN, GARY	12	0.27 - 1.13	ND
6	AR, PINE BLUFF	10	0.2 - 3.0	ND
	LA, LAKE CHARLES	8	0.07 - 0.53	ND
7	IA, DES MOINES	14	0.5 - 3.0	ND
9	CA, SAN FRANCISCO	27	1.0 - 8.0	ND
10	WA, TACOMA	7	0.33 - 0.98	ND
		204		

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[a] Sampling was conducted in the SMSAS for these cities.

[b] Contamination defined as detectable levels.

TABLE 3-6. ANALYTICAL RESULTS FOR CONTAMINATED TIER 7 FISH SITES - STATISTICALLY SELECTED SITES

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES						
1	ME ANDROSCOGGIN RIVER - BRUNSWICK	BOTTOM FEEDER	WHOLE FISH	1	19	1
		BOTTOM FEEDER	FILET	1	11	0.6
3	MD SUSQUEHANNA RIVER - CONOWINGO	BOTTOM FEEDER	WHOLE FISH	1	1.2	0.8
		BOTTOM FEEDER	FILET	1	0.5	0.1
3	PA SCHUYLKILL RIVER - PHILADELPHIA	BOTTOM FEEDER	WHOLE FISH	2	1.2	0.1
		BOTTOM FEEDER	FILET	0	ND	0.7
		PREDATOR	WHOLE FISH	1	1.9	0.2
		PREDATOR	FILET	0	ND	0.5
4	MS YAZOO RIVER - REDWOOD	PREDATOR	WHOLE FISH	2	3.2	1.1
		PREDATOR	FILET	0	ND	1.2
5	IN WABASH RIVER - NEW HARMONY	BOTTOM FEEDER	WHOLE FISH	1	2	0.3
		BOTTOM FEEDER	FILET	0	ND	0.9
		PREDATOR	WHOLE FISH	0	ND	0.9
5	MI MUSKEGON RIVER - BRIDGETON	BOTTOM FEEDER	WHOLE FISH	1	2.8	0.1
		BOTTOM FEEDER	FILET	0	ND	0.6
		PREDATOR	WHOLE FISH	1	4.3	0.1
		PREDATOR	FILET	0	ND	0.4
5	MN RAINY RIVER - LONG SAULT	BOTTOM FEEDER	WHOLE FISH	1	19	1.2
		PREDATOR	WHOLE FISH	1	12	2

TABLE 3-6. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES						
5	OH GREAT MIAMI RIVER - NEW BALTIMORE					
		BOTTOM FEEDER	WHOLE FISH	0	ND	4.6
		PREDATOR	WHOLE FISH	1	1.2	0.08
5	OH LITTLE MIAMI RIVER - MILFORD					
		BOTTOM FEEDER	WHOLE FISH	1	1.2	0.18
5	WI NEMADJI RIVER - SOUTH SUPERIOR					
		BOTTOM FEEDER	WHOLE FISH	1	4	0.2
		BOTTOM FEEDER	FILET	1	0.9	0.4
		PREDATOR	WHOLE FISH	1	1.5	0.6
6	AR MISSISSIPPI RIVER - ARKANSAS CITY					
		BOTTOM FEEDER	WHOLE FISH	1	3.7	0.4
		PREDATOR	WHOLE FISH	1	2.4	0.96
6	AR RED RIVER - INDEX					
		BOTTOM FEEDER	WHOLE FISH	1	6	0.8
		BOTTOM FEEDER	FILET	1	1.9	0.3
6	LA BEOUF RIVER - FT. NECESSITY					
		BOTTOM FEEDER	WHOLE FISH	1	7	0.2
		BOTTOM FEEDER	FILET	0	ND	0.3
		PREDATOR	WHOLE FISH	1	1.1	0.4
		PREDATOR	FILET	0	ND	0.6

TABLE 3-6. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
6	OK WASHITA RIVER - DURWOOD					
		BOTTOM FEEDER	WHOLE FISH	1	1.3	0.32
		BOTTOM FEEDER	FISH	0	ND	0.39
		PREDATOR	WHOLE FISH	0	ND	0.38
		PREDATOR	FILET	0	ND	0.34
7	NE PLATTE RIVER - LOUISVILLE					
		BOTTOM FEEDER	WHOLE FISH	1	2	0.4
		BOTTOM FEEDER	FILET	0	ND	1.4
9	CA OWENS RIVER - BIG PINE					
		BOTTOM FEEDER	WHOLE FISH	1	1.2	0.8
		BOTTOM FEEDER	FILET	0	ND	1.3
		PREDATOR	WHOLE FISH	0	ND	0.7
10	OR WILLAMETTE RIVER - PORTLAND					
		BOTTOM FEEDER	WHOLE FISH	2	4.5	1.1
		BOTTOM FEEDER	FILET	1	1.5	0.73

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[a] Contamination defined as detectable levels.

TABLE 3-7. ANALYTICAL RESULTS FOR CONTAMINATED TIER 7 FISH SITES - REGIONALLY SELECTED SITES

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED [a] SITES						
1	CT QUINIPIAC RIVER - NORTH HAVEN					
		BOTTOM FEEDER	WHOLE FISH	1	0.9	0.3
		BOTTOM FEEDER	FILET	0	ND	0.66
1	MA BLACKSTONE RIVER - MILLVILLE					
		BOTTOM FEEDER	WHOLE FISH	1	1.1	0.05
		BOTTOM FEEDER	FILET	1	0.4	0.13
		PREDATOR	WHOLE FISH	1	2.4	0.1
		PREDATOR	FILET	0	ND	0.76
1	MA MERRIMACK RIVER - TYNGS ISLAND					
		BOTTOM FEEDER	WHOLE FISH	1	1.2	0.24
1	MA NASHUA RIVER - PEPPERELL					
		BOTTOM FEEDER	WHOLE FISH	1	3.3	0.5
		BOTTOM FEEDER	FILET	0	ND	0.7
		PREDATOR	WHOLE FISH	1	3.5	0.3
		PREDATOR	FILET	0	ND	1.1
1	ME ANDROSCOGGIN RIVER - LEWISTON					
		BOTTOM FEEDER	WHOLE FISH	1	29	0.32
		BOTTOM FEEDER	FILET	1	4.6	0.43
		PREDATOR	WHOLE FISH	1	24	0.5
		PREDATOR	FILET	1	4.5	0.47
1	ME KENNEBEC RIVER - SIDNEY					
		BOTTOM FEEDER	WHOLE FISH	1	11.4	0.02
		BOTTOM FEEDER	FILET	1	1.2	0.4
		PREDATOR	WHOLE FISH	1	20.3	0.4

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED [a] SITES						
1	ME PENOBSCOT RIVER - EDDINGTON	BOTTOM FEEDER	WHOLE FISH	1	7.6	0.2
		BOTTOM FEEDER	FILET	1	2.6	0.45
		PREDATOR	WHOLE FISH	1	4.6	0.5
1	VT CONNECTICUT RIVER - NEWBURY	BOTTOM FEEDER	WHOLE FISH	1	1.6	0.11
		BOTTOM FEEDER	FILET	0	ND	0.6
		PREDATOR	WHOLE FISH	0	ND	1.4
		PREDATOR	FILET	0	ND	0.4
2	NJ PASSAIC RIVER - PATERSON	BOTTOM FEEDER	WHOLE FISH	1	1.7	3.8
		BOTTOM FEEDER	FILET	1	0.9	0.6
2	NY HUDSON RIVER - PEEKSKILL	BOTTOM FEEDER	WHOLE FISH	1	[illegible].7	0.1
		PREDATOR	WHOLE FISH	1	1.3	0.21
		PREDATOR	FILET	0	ND	0.2
2	NY HUDSON RIVER @ GREEN ISLAND - TROY	BOTTOM FEEDER	WHOLE FISH	1	1.9	0.58
		BOTTOM FEEDER	FILET	0	ND	0.7
		PREDATOR	WHOLE FISH	1	1.2	0.75
		PREDATOR	FILET	0	ND	0.26
3	DC POTOMAC RIVER - EAST POTOMAC PARK	PREDATOR	WHOLE FISH	2	4.9	0.8
		PREDATOR	FILET	2	5	0.9
3	MD POTOMAC RIVER - SHEPHERDSTOWN	PREDATOR	WHOLE FISH	2	4.8	0.5
		PREDATOR	FILET	1	2.9	0.3
3	PA ALLEGHENY RIVER - NEW KENSINGTON	BOTTOM FEEDER	WHOLE FISH	1	1.7	0.44
		PREDATOR	WHOLE FISH	0	ND	1

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED [a] SITES						
3	PA JUNIATA RIVER - NEWPORT					
		BOTTOM FEEDER	WHOLE FISH	1	0.7	0.1
		BOTTOM FEEDER	FILET	0	ND	1
		PREDATOR	WHOLE FISH	0	ND	1.1
		PREDATOR	FILET	0	ND	0.4
3	VA JAMES RIVER - GLASGOW					
		BOTTOM FEEDER	WHOLE FISH	1	4.5	0.8
		BOTTOM FEEDER	FILET	0	ND	1.6
		PREDATOR	WHOLE FISH	1	1.4	0.3
		PREDATOR	FILET	0	ND	1
3	VA SHENANDOAH RIVER - ROCKLAND					
		BOTTOM FEEDER	WHOLE FISH	1	1	1.3
		BOTTOM FEEDER	FILET	0	ND	0.4
		PREDATOR	WHOLE FISH	0	ND	0.2
3	WV OHIO RIVER @ PIKE ISLAND - WHEELING					
		BOTTOM FEEDER	WHOLE FISH	1	1.2	0.1
		BOTTOM FEEDER	FILET	0	ND	1
		PREDATOR	WHOLE FISH	1	1.2	0.2
		PREDATOR	FILET	0	ND	0.6
4	AL ALABAMA RIVER - CLAIBORNE					
		BOTTOM FEEDER	WHOLE FISH	1	23	0.65
		BOTTOM FEEDER	FISH	1	2.4	0.08
		PREDATOR	WHOLE FISH	1	17	0.09
		PREDATOR	FILET	1	12	0.15
4	AL COOSA RIVER - CHILDERSBURG					
		BOTTOM FEEDER	WHOLE FISH	1	15	0.1
		BOTTOM FEEDER	FILET	1	3.2	1.2
		PREDATOR	WHOLE FISH	1	13	1.4
		PREDATOR	FILET	1	6.7	0.3

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION: CONTAMINATED [a] SITES	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
4	AL TENNESSEE RIVER - WATERLOO					
		BOTTOM FEEDER	WHOLE FISH	1	3.5	0.75
		BOTTOM FEEDER	FILET	1	2	0.23
		PREDATOR	WHOLE FISH	0	ND	1.5
		PREDATOR	FILET	0	ND	0.22
4	GA FLINT RIVER, LAKE BLACKSHEAR - CORDELLE					
		BOTTOM FEEDER	WHOLE FISH	1	1.3	0.1
		PREDATOR	FILET	1	1.1	0.08
4	GA SAVANNAH RIVER - AUGUSTA					
		BOTTOM FEEDER	WHOLE FISH	1	3	0.3
		BOTTOM FEEDER	FILET	1	8.1	1.6
		PREDATOR	WHOLE FISH	1	5.1	0.1
4	KY KENTUCKY RIVER - GEST					
		BOTTOM FEEDER	WHOLE FISH	1	0.8	0.23
		BOTTOM FEEDER	FILET	0	ND	0.45
		PREDATOR	WHOLE FISH	0	ND	0.31
		PREDATOR	FILET	0	ND	0.62
4	KY OHIO RIVER - CANNELTON DAM					
		BOTTOM FEEDER	WHOLE FISH	1	3.9	0.24
		BOTTOM FEEDER	FILET	0	ND	1.2
		PREDATOR	WHOLE FISH	1	4.1	0.13
		PREDATOR	FILET	0	ND	2.6
4	KY OHIO RIVER - MARKLAND DAM					
		BOTTOM FEEDER	WHOLE FISH	1	13	1.1
		BOTTOM FEEDER	FILET	1	6.4	0.06
		PREDATOR	WHOLE FISH	1	4.2	0.06
		PREDATOR	FILET	0	ND	0.53
4	KY OHIO RIVER - UNIONTOWN					
		BOTTOM FEEDER	WHOLE FISH	1	3.4	1.6
		PREDATOR	WHOLE FISH	0	ND	0.9

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED [a] SITES						
4	KY OHIO RIVER - WESTPOINT	BOTTOM FEEDER	WHOLE FISH	1	5.2	0.3
		PREDATOR	WHOLE FISH	1	2.1	0.4
4	MS BIG BLACK RIVER - BOVINA	BOTTOM FEEDER	WHOLE FISH	1	2.2	0.1
		BOTTOM FEEDER	FILET	0	ND	0.64
		PREDATOR	WHOLE FISH	0	ND	0.4
		PREDATOR	FILET	0	ND	0.9
4	MS HOMOCHITTO RIVER - ROSETTA	PREDATOR	WHOLE FISH	2	1.8	0.5
		PREDATOR	FILET	1	2.6	0.3
4	MS PASCAGOULA RIVER - BENNDALE	BOTTOM FEEDER	WHOLE FISH	1	5.2	0.7
		BOTTOM FEEDER	FILET	0	ND	2.9
		PREDATOR	WHOLE FISH	1	2.7	0.2
		PREDATOR	FILET	0	ND	0.67
4	NC CATAWBA RIVER - LAKE HICKORY	BOTTOM FEEDER	WHOLE FISH	1	1.5	0.21
		BOTTOM FEEDER	FILET	0	ND	0.7
		PREDATOR	WHOLE FISH	0	ND	0.4
		PREDATOR	FILET	0	ND	0.6
4	SC LAKE MURRAY - PROSPERITY	BOTTOM FEEDER	WHOLE FISH	1	3.7	0.1
		BOTTOM FEEDER	FILET	1	1	0.74
		PREDATOR	WHOLE FISH	0	ND	1.4
		PREDATOR	FILET	0	ND	1.3
4	SC PEE DEE RIVER - PEE DEE	BOTTOM FEEDER	WHOLE FISH	1	2.3	0.6
		BOTTOM FEEDER	FILET	1	3.9	0.1
		PREDATOR	WHOLE FISH	0	ND	0.7
		PREDATOR	FILET	0	ND	0.8

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION: CONTAMINATED [a] SITES	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
5	IL DES PLAINES RIVER - LOCKPORT					
		BOTTOM FEEDER	WHOLE FISH	1	12	0.6
		BOTTOM FEEDER	FILET	1	8.9	0.1
5	IL ILLINOIS RIVER - FLORENCE					
		BOTTOM FEEDER	WHOLE FISH	1	2.7	0.5
		BOTTOM FEEDER	FILET	0	ND	0.92
		PREDATOR	WHOLE FISH	0	ND	0.69
		PREDATOR	FILET	0	ND	0.36
5	IL ILLINOIS RIVER - MARSEILLES					
		BOTTOM FEEDER	WHOLE FISH	1	15	0.7
		BOTTOM FEEDER	FILET	1	7	0.3
5	IL KASKASKIA RIVER - VANDALIA					
		BOTTOM FEEDER	WHOLE FISH	1	1.2	1
		BOTTOM FEEDER	FILET	0	ND	0.7
		PREDATOR	WHOLE FISH	0	ND	3
5	IL MISSISSIPPI RIVER - THEBES					
		BOTTOM FEEDER	WHOLE FISH	1	5.4	0.3
		BOTTOM FEEDER	FILET	0	ND	1.6
		PREDATOR	WHOLE FISH	0	ND	1.6
5	IN GRAND CALUMET RIVER - HAMMOND					
		BOTTOM FEEDER	WHOLE FISH	1	8	0.1
5	IN MISSISSNEWA RIVER - MATTHEWS					
		BOTTOM FEEDER	WHOLE FISH	1	1	0.1
		BOTTOM FEEDER	FILET	0	ND	1.1
		PREDATOR	WHOLE FISH	1	2	0.1
		PREDATOR	FILET	0	ND	0.8
5	IN WABASH RIVER - BLACKROCK					
		BOTTOM FEEDER	WHOLE FISH	1	1.4	0.2
		BOTTOM FEEDER	FILET	0	ND	0.4

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION: CONTAMINATED[a] SITES	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
5	MI CLINTON RIVER - MT. CLEMENS					
		BOTTOM FEEDER	WHOLE FISH	1	2.6	0.3
5	MI FLINT RIVER, ELMS ROAD - FLINT					
		BOTTOM FEEDER	WHOLE FISH	1	28	0.02
		BOTTOM FEEDER	FILET	1	5.1	0.23
		PREDATOR	WHOLE FISH	1	1.6	0.23
		PREDATOR	FILET	0	ND	0.12
5	MI KALAMAZOO RIVER - LAKE ALLEGAN	BOTTOM FEEDER	WHOLE FISH	1	3	0.7
5	MI MUSKEGON LAKE - MUSKEGON					
		BOTTOM FEEDER	WHOLE FISH	0	ND	1.4
		BOTTOM FEEDER	F(skinless)	1	5.2	2
		PREDATOR	WHOLE FISH	1	3.9	1.6
		PREDATOR	F(skinless)	0	ND	2.4
5	MI PINE RIVER - ALMA					
		BOTTOM FEEDER	WHOLE FISH	1	8.6	0.4
5	MI ST. CLAIR RIVER - ALGONAC					
		BOTTOM FEEDER	WHOLE FISH	1	4.9	0.3
5	MN RAINY RIVER - INTERNATIONAL FALLS					
		BOTTOM FEEDER	WHOLE FISH	1	23	0.52
		BOTTOM FEEDER	FILET	1	5.9	0.1
		PREDATOR	WHOLE FISH	1	85	0.11
5	OH GREAT MIAMI RIVER - FRANKLIN					
		BOTTOM FEEDER	WHOLE FISH	1	4.8	1
		PREDATOR	WHOLE FISH	1	1.8	0.13
5	OH GREAT MIAMI RIVER - HAMILTON					
		BOTTOM FEEDER	WHOLE FISH	2	3.7	0.3
		BOTTOM FEEDER	FILET	0	ND	0.6

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED [a] SITES						
5	OH OHIO RIVER - EAST LIVERPOOL	BOTTOM FEEDER	WHOLE FISH	1	0.9	0.16
		PREDATOR	WHOLE FISH	1	1.08	0.03
5	OH OHIO RIVER - GALLIPOLIS	PREDATOR	WHOLE FISH	1	4	0.6
5	OH OHIO RIVER - MARIETTA	BOTTOM FEEDER	WHOLE FISH	1	3.6	0.03
		PREDATOR	WHOLE FISH	1	0.97	0.23
5	OH OHIO RIVER - PORTSMOUTH	BOTTOM FEEDER	WHOLE FISH	1	2	0.36
		PREDATOR	WHOLE FISH	1	3.1	0.3
5	OH SCIOTO RIVER - CIRCLEVILLE	BOTTOM FEEDER	WHOLE FISH	1	3.2	0.19
		PREDATOR	WHOLE FISH	1	2.7	0.4
5	WI BLACK RIVER - BLACK RIVER FALLS	BOTTOM FEEDER	WHOLE FISH	1	4.7	0.2
		BOTTOM FEEDER	FILET	0	ND	1.4
		PREDATOR	WHOLE FISH	0	ND	0.9
		PREDATOR	FILET	0	ND	0.9
5	WI ST. CROIX RIVER - ST. CROIX FALLS	BOTTOM FEEDER	WHOLE FISH	1	1.8	0.7
		BOTTOM FEEDER	FILET	0	ND	1.1
		PREDATOR	WHOLE FISH	0	ND	0.3
		PREDATOR	FILET	0	ND	0.5
6	LA BAYOU LAFOURCHE - MATHEWS	BOTTOM FEEDER	WHOLE FISH	1	1.9	0.2
		BOTTOM FEEDER	FILET	0	ND	0.72
		PREDATOR	WHOLE FISH	1	1.9	0.1
		PREDATOR	FILET	0	ND	0.67

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED [a] SITES						
6	LA MISSISSIPPI RIVER - ST. FRANCISVILLE					
		BOTTOM FEEDER	WHOLE FISH	1	5.3	0.9
		BOTTOM FEEDER	FILET	0	ND	1
		PREDATOR	WHOLE FISH	1	0.7	0.2
		PREDATOR	FILET	1	0.8	0.2
6	TX SAN JACINTO RIVER - LAKE HOUSTON					
		BOTTOM FEEDER	WHOLE FISH	1	2.8	0.1
		BOTTOM FEEDER	FILET	0	ND	0.4
		PREDATOR	WHOLE FISH	0	ND	1.7
		PREDATOR	FILET	0	ND	1.2
7	IA BIG SIOUX RIVER - AKRON					
		BOTTOM FEEDER	WHOLE FISH	1	1.3	0.1
		BOTTOM FEEDER	FILET	0	ND	0.4
7	KS ARKANSAS RIVER - DERBY					
		BOTTOM FEEDER	WHOLE FISH	1	0.8	0.5
		BOTTOM FEEDER	FILET	0	ND	0.2
7	KS NEOSHO RIVER - CHETOPA					
		BOTTOM FEEDER	WHOLE FISH	1	2.4	1.2
		BOTTOM FEEDER	FILET	0	ND	0.5
		PREDATOR	WHOLE FISH	0	ND	0.7
		PREDATOR	FILET	0	ND	0.7
7	KS TUTTLE CREEK RESERVOIR					
		BOTTOM FEEDER	WHOLE FISH	1	4.7	0.3
		BOTTOM FEEDER	FILET	0	ND	1.1
		PREDATOR	WHOLE FISH	0	ND	0.7
		PREDATOR	FILET	0	ND	0.8
7	MO LITTLE RIVER DITCHES - HORNERSVILLE					
		BOTTOM FEEDER	WHOLE FISH	1	1.9	0.5
		BOTTOM FEEDER	FILET	1	0.4	0.2
		PREDATOR	WHOLE FISH	1	1.3	0.2
		PREDATOR	FILET	0	ND	0.6

TABLE 3-7. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	# DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED [a] SITES						
7	MO MISSOURI RIVER - LEXINGTON	BOTTOM FEEDER	WHOLE FISH	1	1.8	0.2
		BOTTOM FEEDER	FILET	0	ND	0.6
		PREDATOR	WHOLE FISH	0	ND	0.6
		PREDATOR	FILET	0	ND	0.1
7	MO ST. FRANCIS RIVER - CARDWELL	BOTTOM FEEDER	WHOLE FISH	1	3.4	0.21
8	ND RED RIVER - PEMBINA	BOTTOM FEEDER	WHOLE FISH	1	1.8	0.72
		BOTTOM FEEDER	FILET	0	ND	0.8
		PREDATOR	WHOLE FISH	0	ND	0.72

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[a] Contamination defined as detectable levels.

TABLE 3-8. ANALYTICAL RESULTS FOR CONTAMINATED TIER 7 FISH SITES - GREAT LAKES AREA

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	NO. DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES						
2	NY LAKE ONTARIO--BUFFALO RIVER					
		BOTTOM FEEDER	WHOLE FISH	1	1.9	0.6
		BOTTOM FEEDER	FILET	1	0.76	0.4
	NY LAKE ONTARIO--EIGHTEEN MILE CREEK					
		BOTTOM FEEDER	WHOLE FISH	1	6.3	0.5
		BOTTOM FEEDER	FILET	0	ND	0.65
		PREDATOR	WHOLE FISH	1	20	0.2
		PREDATOR	FILET	1	3.6	0.5
	NY LAKE ONTARIO--NIAGARA RIVER					
		BOTTOM FEEDER	WHOLE FISH	1	11	0.4
		BOTTOM FEEDER	FILET	1	8.4	0.1
		PREDATOR	WHOLE FISH	1	5.8	0.1
		PREDATOR	FILET	1	2.3	0.1
	NY LAKE ONTARIO--OLCOTT					
		PREDATOR	WHOLE FISH	1	18	1.4
		PREDATOR	FILET	1	13	0.7
	NY LAKE ONTARIO--ROCHESTER					
		PREDATOR	WHOLE FISH	1	13	0.6
		PREDATOR	FILET	1	12	0.3
	NY LAKE ONTARIO--WILSON					
		PREDATOR	WHOLE FISH	1	23	0.3
		PREDATOR	FILET	1	9	0.9

[a] Contamination defined as detectable levels.

TABLE 3-8. (CONT.)

REGION	LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	NO. DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED^{a} SITES						
5	MI LAKE ERIE--TRENTON CHANNEL	BOTTOM FEEDER	WHOLE FISH	1	14	0.8
		BOTTOM FEEDER	FILET	1	2.7	0.1
		PREDATOR	WHOLE FISH	0	ND	1.6
		PREDATOR	FILET	0	ND	0.4
	MI LAKE ERIE--RIVER ROUGE	BOTTOM FEEDER	WHOLE FISH	1	24.1	1.8
		BOTTOM FEEDER	FILET	1	4.4	0.26
		PREDATOR	WHOLE FISH	1	3.4	1.01
		PREDATOR	FILET	0	ND	0.68
	MI LAKE ERIE--DETROIT RIVER	BOTTOM FEEDER	WHOLE FISH	1	9.1	0.1
		BOTTOM FEEDER	FILET	1	8	0.1
		PREDATOR	WHOLE FISH	2	3.8	0.1
		PREDATOR	FILET	0	ND	0.58
	MI LAKE MICHIGAN--ROCKPORT	PREDATOR	WHOLE FISH	1	5.0	1.1
		PREDATOR	FILET	1	9.8	0.2
	MI LAKE MICHIGAN--SANGATUCK	PREDATOR	WHOLE FISH	1	4.0	1.4
		PREDATOR	FILET	1	6.5	0.25
	MI LAKE MICHIGAN--WHITE LAKE	BOTTOM FEEDER	WHOLE FISH	2	1.8	0.45
		BOTTOM FEEDER	FILET	0	ND	0.21
		PREDATOR	WHOLE FISH	1	1.1	0.1
		PREDATOR	FILET	0	ND	0.43
	MI LAKE ST. CLAIR--ANCHOR BAY	PREDATOR	WHOLE FISH	1	5.8	0.95
		PREDATOR	FILET	1	2.3	0.3

TABLE 3-8. (CONT.)

REGION LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	NO. DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES					
MI LAKE HURON--SAGINAW BAY--CASEVILLE	BOTTOM FEEDER	WHOLE FISH	1	18	0.5
	BOTTOM FEEDER	FILET	1	13.2	0.4
	PREDATOR	WHOLE FISH	1	6.8	0.1
	PREDATOR	FILET	1	0.7	0.2
NY LAKE ONTARIO--OSWEGO	PREDATOR	FILET	2	41	1.1
OH LAKE ERIE--BLACK RIVER	BOTTOM FEEDER	WHOLE FISH	1	2.4	1
OH LAKE ERIE--CUYAHOGA RIVER	BOTTOM FEEDER	WHOLE FISH	1	3.1	0.19
WI LAKE MICHIGAN--FOX RIVER	BOTTOM FEEDER	WHOLE FISH	1	5.3	0.3
	BOTTOM FEEDER	FILET	1	1.2	0.3
	PREDATOR	WHOLE FISH	1	6	1.5
	PREDATOR	FILET	0	ND	0.48
WI LAKE MICHIGAN--MENOMINEE RIVER	BOTTOM FEEDER	WHOLE FISH	1	7.3	0.7
	BOTTOM FEEDER	FILET	1	8	0.1
	PREDATOR	WHOLE FISH	1	1.4	0.1
	PREDATOR	FILET	1	1.8	0.2
WI LAKE MICHIGAN--OCONTO RIVER	BOTTOM FEEDER	WHOLE FISH	1	3.6	0.5
	BOTTOM FEEDER	FISH	1	1.2	0.2
	PREDATOR	WHOLE FISH	0	ND	1.5
	PREDATOR	FILET	0	ND	0.2

TABLE 3-8. (CONT.)

REGION LOCATION DESCRIPTION:	TYPE OF FISH	CUT OF SAMPLE	NO. DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES					
WI LAKE MICHIGAN--PESTIGO RIVER					
	BOTTOM FEEDER	WHOLE FISH	1	8.5	0.6
	BOTTOM FEEDER	FILET	1	3.5	0.29
	PREDATOR	WHOLE FISH	1	1.5	0.38
	PREDATOR	FILET	0	ND	0.22
WI LAKE SUPERIOR--ASHLAND					
	BOTTOM FEEDER	WHOLE FISH	1	4.8	0.4
	BOTTOM FEEDER	FILET	0	ND	1.3
WI LAKE SUPERIOR--SUPERIOR					
	BOTTOM FEEDER	WHOLE FISH	1	15	0.2
	BOTTOM FEEDER	FILET	1	5.2	0.71
	PREDATOR	WHOLE FISH	1	5.2	0.46
	PREDATOR	FILET	0	ND	1.2

TABLE 3-9. RESULTS OF ANALYSES OF TIER 7 FISH - ESTUARINE AREAS

REGION	LOCATION DESCRIPTION:	MATRIX TYPE	NO. SAMPLED	NO. DETECTED	VALUE (PPT)	DET LIMIT (PPT)
CONTAMINATED[a] SITES						
1	RI NARRAGANSETT BAY--NARRAGANSETT					
		MUSSELS	1	1	3.5	1.7
2	NJ SANDY HOOK BAY--LEONARD					
		MUSSELS	1	1	1.08	0.03
6	LA GARDEN ISLAND BAY--VENICE					
		FISH-FILET	1	0	ND	1.8
		FISH-WHOLE	1	1	3.3	0.1
	TX TRINITY BAY					
		OYSTERS	1	1	2.2	0.3

[a] Contamination defined as detectable levels

Chapter Four

COMBUSTION SOURCES

4.1 Objectives

Tier 4 was designed as a screening study to determine which combustion source categories emit CDDs and at what concentrations. The main focus was on releases to the ambient air; however, other samples, such as ash and scrubber water, were also obtained to determine if these compounds are released to other media. Because some combustion sources were known to emit a wide range of CDD and CDF compounds, tier 4 samples were analyzed for specific homologues of CDDs and CDFs as well as for 2,3,7,8-TCDD, the compound of most specific concern.

4.2 Background

There are millions of combustion sources in the United States. Residential heating units burn oil, gas, coal, and wood for heat. Larger commercial, institutional, and utility boilers burn fossil fuels to generate heat and electricity. Many industrial processes burn fuels and other raw or waste materials to produce heat and/or to recover products of marketable value. Other processes, such as incineration, use combustion to reduce the volume of unwanted waste products and to recover heat and other resources from the waste products. Open fires, both accidental (e.g., structural and forest fires) and intentional, (i.e., those set for forest management and agricultural burning) are other examples of combustion sources.

Assessment of CDD and CDF emissions from combustion sources has been limited. Previous work included studies of emissions from hazardous waste incinerators, utility boilers and municipal waste combustion. Even for those source categories that have been tested, there is considerable variation in both the extent and quality of testing and the test methods employed.

4.3 Study Design

It was impractical to test all of the combustion source categories under tier 4. A study plan was developed that identified those source categories which were believed to have the greatest potential for CDD emissions. Selection and prioritization of source categories for testing were based upon a review of CDD-related studies reported in the literature, and on engineering judgment (EPA, 1984c). Information from this review suggested that the following conditions were most important for CDD formation:

1. Presence of CDD in the materials being burned;
2. Presence of CDD precursors in the materials being burned (e.g., chlorinated phenols, chlorinated benzenes); and
3. Presence of chlorine, fuel and combustion conditions conducive to CDD formation, including:
    - (a) Relatively low combustion temperature (500-800°C);
    - (b) Short residence time of fuel in the combustion zone (<1-2 seconds);
    - (c) Inadequate oxygen (resulting in incomplete combustion);
    - (d) Inadequate processing of fuels (e.g., burning of wet garbage); and
    - (e) Lack of supplemental fuel to promote combustion efficiency.

Based on a relatively subjective determination of which combustion source categories were most closely associated with these factors, judgments were made regarding the potential of various source categories to emit CDDs. Certain source categories judged to have a relatively low potential to emit CDDs were not given further consideration for testing. For example, process heaters and gas turbines were believed to have low potential because of their higher combustion efficiencies and their use of fuels with low chlorine content (e.g., natural gas).

Municipal waste combustors, sewage sludge incinerators and recovery boilers at kraft paper mills were identified as large source categories with the potential to emit CCDs. Table 4-1

TABLE 4-1. COMBUSTION SOURCE CATEGORIES WHERE ASH AND STACK SAMPLES WERE COLLECTED

	Sample Type	
Source Categories Sampled	Ash	Stack
Sewage Sludge Incinerator	X	X (3)[a]
Kraft Paper Recovery Boiler	X	X (3)
Industrial Waste Incinerator	X	X (1)
Wire Reclamation Incinerator	X	X (1)
Secondary Copper Smelter	X	X (1)
Carbon Regeneration Furnace	X	X (1)
Drum and Barrel Furnace	X	X (1)
Wood Stove	X	X (1)
Wood-fired Boiler	X	X (1)
Charcoal Manufacturing Oven	X	
Mobile Source		X (2)
Utility Boiler	X	
Small Spreader-Stoker Coal-fired Boiler	X	
Commercial Boiler	X	
Kiln Burning Hazardous Waste	X	
Open Burning/Accidental Fire	X	
Sulfite Liquor Boiler	X	
Apartment House Incinerator	X	
Hazardous Waste Incinerator	X	
Hospital Incinerator	X	
Municipal Waste Combustor	X	
Charcoal Grill	X	

[a] Number in parentheses indicates how many sources in the specified source category were stack tested under tier 4.

lists the source categories identified by the prioritization effort. A more complete explanation of the selection and prioritization process is contained in the tier 4 Project Plan.

The Project Plan was widely circulated for comment prior to implementation. Some of the source categories in Table 4-1 were included primarily on the basis of reviewers' recommendations. A few source categories (wood stoves and mobile sources) were included because these sources were being tested for other purposes, and the add-on cost of CDD/CDF testing was small. Adjustments were made to the initial list as the study progressed.

Tier 4 sampling efforts focused on source categories that had not been widely tested. Although some municipal waste combustors (MWCs) were known to emit CDDs, no additional stack testing of this source category was performed directly under tier 4.* Compared to most other source categories, a relatively large data base already existed. In addition, other air pollution control agencies, e.g., the New York Department of Environmental Conservation and Environment Canada, were either conducting or planning data collection studies for MWCs. Selected MWC emission data and ash sampling results are summarized later in this report.

4.3.1 Sample Collection

Two types of testing were considered for each of the source categories listed in Table 4-1:

Stack Sampling

Stack sampling provides the best quantitative measurement of emissions; however, it is expensive (e.g., $50,000-100,000 per source, not including analytical costs). Where possible, stack gas samples were collected both before (inlet) and after (outlet) any pollution control device. Ash, feed, and soil samples were also collected at sites that were stack tested.

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* Subsequent to this decision, Congress directed EPA to provide a report specifically on municipal incinerator emissions of CDDs under the requirements of Section 102 of the Hazardous and Solid Waste Act of 1984.

Because of the high costs, only 13 sources could be stack tested. Three kraft paper recovery boilers and three sewage sludge incinerators were tested because they appeared to have conditions particularly conducive to CDD formation. Only one source in each of the other selected source categories was tested. The focus of the testing program was primarily on sources believed to be indicative of average to worst case emission situations.

Ash Sampling

Ash samples were collected from air pollution control devices (fly ash) or from residues of combustion (bottom ash) to provide an indication of the presence of CDDs. A secondary objective of the tier 4 study was to examine possible relationships between ash and stack test results. If such a relationship could be determined, inexpensive ash samples could be used in lieu of expensive stack testing to identify source categories with high CDD/CDF emission rates. Use of ash data is currently limited because observed correlations between levels of CDDs in fly ash and CDD stack emissions are not sufficient for quantitative use. Ash samples were generally collected from three sources in each of the source categories listed in Table 4-1.

4.3.2 Site Selection

Selection of test sites for stack and ash sampling was based on a number of factors. EPA Regional Offices recommended sources based on the criteria outlined in the Project Plan (EPA, 1985b). A technical analysis was conducted to determine the operational parameters for a particular source category that would likely result in a "representative" to "worst-case" emission situation. Candidate sources were contacted, and pre-test survey visits conducted, to identify plants with operations most closely resembling the hypothesized conditions, which had acceptable stack sampling locations.

Once a site was selected for stack testing, a detailed pretest plan was prepared which described the physical layout of the source, the location, number, and types of samples to be collected, and associated quality assurance activities. After the test was completed, a separate report for each site was prepared that described the actual testing performed and the test results.

Ash sampling sites were generally selected based upon recommendations from Regional, State and local environmental agencies. Ease of sampling and level of participation by the agencies were considered in those cases where several facilities appeared to be of equal interest. Ash samples were collected by State and local agencies and EPA contractors during the surveys of candidate sources for the stack sampling program, as part of actual stack sampling, and from selected additional facilities.

4.3.3 Sampling Procedure and Analyses

Consistent sample collection procedures were used at all sites. Sampling methodologies and procedures are described in three tier 4 protocol documents. One document describes the ash sampling procedures, a second the stack sampling procedures, and a third the quality assurance measures and procedures (EPA, 1985c, 1984d, 1985d). The stack testing method used at tier 4 sampling sites is the state-of-the-art method proposed for use by a joint American Society of Mechanical Engineers (ASME) and EPA Work Group for municipal incinerators, with minor modifications. This procedure, which uses a modified EPA Method 5 sampling train, is described in detail in the stack test protocol document.

EPA's "Troika" of three in-house laboratories was responsible for the analyses, as well as for the preparation of the CDD and CDF analytical protocols and laboratory quality control procedures to be used with tier 4 samples. Analytical methods are described in an addendum to a Troika procedures document (EPA, 1986e).

While the Troika was responsible for all CDD and CDF analyses, an EPA contractor (Radian Corporation) provided support for the analyses of other compounds. For example, samples of the fuels and other feed materials at each site were analyzed to determine the presence of possible precursors (e.g., chlorinated benzenes, biphenyls, and phenols). In addition, continuous emissions data were collected for various stack gases (e.g., CO, CO_2, O_2) during each stack test. Analytical procedures used for these analyses are described in a separate report (EPA, 1986f).

A second EPA contractor (Research Triangle Institute) conducted the quality assurance program, which included auditing three stack tests and introducing audit samples into the laboratories to evaluate their performance. The independent quality assurance program is described in a separate report (EPA, 1985d).

4.4 Results

Approximately 350 samples were collected, 20-25 percent of which were for internal quality assurance purposes. Thirteen sources were stack tested and 72 sites were tested under the ash sampling program. Collected samples were sent to the appropriate analytical laboratory in accordance with established procedures.

4.4.1 Tier 4 Stack Test Results

Table 4-2 contains the CDD results for the 13 sites tested, while Table 4-3 presents the CDF results. Data presented in these tables represent concentrations of emissions measured in the stack gases. CDD/CDF stack concentrations have been normalized to a 3 percent oxygen concentration. This removes the effect of dilution, and is a more appropriate means of comparing combustion processes.

There is considerable variation in the concentrations among the sources tested under tier 4. Each of the sources with valid data had detectable levels of CDDs and CDFs, although not all had

TABLE 4-2. TIER 4 CDD STACK TESTING RESULTS

(ng/dscm @ 3% O_2)[a]

Source	2,3,7,8-TCDD	Chlorinated Dibenzo-p-dioxin Homologues					
		Other Tetra-	Penta-	Hexa-	Hepta-	Octa-	Total[b] Tetra-Octa
Drum and Barrel Furnace	0.05	1.2	0.72	0.79	1.3	0.92	5.0
Industrial Carbon Regenerator	ND[c]	0.57	0.44	0.98	0.90	0.81	3.7
Industrial Waste Incinerator	4.5	77	100	150	230	61	630
Kraft Paper Recovery Boilers							
Plant A	ND	ND	ND	0.06	0.18	0.49	0.73
Plant B	ND	ND	ND	0.10	0.26	0.83	1.2
Plant C	ND	0.13	0.15	0.39	0.88	1.4	2.9
Secondary Copper Smelter[d]	170	1400	2300	2200	5900	3700	16,000
Sewage Sludge Incinerators							
Plant A	0.05	11	0.18	0.51	2.5	5.3	20
Plant B	ND	0.40	ND	ND	0.22	0.98	1.6
Plant C	0.14	8.1	1.1	7.0	21	15	53
Wire Reclamation Incinerator[d]	0.07	1.2	2.2	14	130	290	440
Wood-fired Boiler (Salt Laden Wood)	0.28	47	48	49	39	11	200
Wood Stoves	NR[e]	NR	NR	NR	NR	NR	NR

[a] ng/dscm @ 3% O_2 = nanograms per standard cubic meter of flue gas, normalized to 3 percent oxygen.

[b] Numbers across may not add up to totals due to rounding.

[c] ND = Not detected, generally at less than 0.1 ng/dscm @ 3% O_2.

[d] Estimated values. Stack sampling results for this site do not meet analytical quality assurance objectives, but represent lower level estimates.

[e] NR = Not reported due to organic interference.

TABLE 4-3. TIER 4 CDF STACK TESTING RESULTS

(ng/dscm @ 3% O_2)[a]

Source	2,3,7,8-TCDF	Chlorinated Dibenzofuran Homologues					
		Other Tetra-	Penta-	Hexa-	Hepta-	Octa-	Total[b] Tetra-Octa
Drum and Barrel Furnace	0.90	14	6.2	3.0	2.0	0.55	27
Industrial Carbon Regenerator	ND[c]	1.2	0.37	0.59	0.61	0.54	3.3
Industrial Waste Incinerator	21	570	610	650	470	66	2400
Kraft Paper Mill Recovery Boilers							
Plant A	0.02	0.16	0.06	0.07	0.16	0.13	0.59
Plant B	0.01	0.13	ND	0.34	0.17	0.07	0.71
Plant C	0.01	0.46	0.46	0.59	0.50	0.09	2.1
Secondary Copper Smelter[d]	5100	18,000	19,000	6000	11,000	7200	65,000
Sewage Sludge Incinerators							
Plant A	NR[e]	33	10	0.10	0.5	0.10	44
Plant B	2.1	19	4.8	1.6	ND	0.07	28
Plant C	54	150	110	32	60	45	450
Wire Reclamation Incinerator[d]	0.40	29	22	65	230	230	580
Wood-fired Boiler (Salt Laden Wood)	1.8	37	23	13	6.5	0.92	83
Wood Stoves	NR	NR	NR	NR	NR	NR	NR

[a] ng/dscm @ 3% O_2 = nanograms per standard cubic meter of flue gas, normalized to 3 percent oxygen.

[b] Numbers across may not add up to totals due to rounding.

[c] ND = Not detected, generally at less than 0.1 ng/dscm @ 3% O_2.

[d] Estimated values. Stack sampling results for this site do not meet analytical quality assurance objectives, but represent lower level estimates.

[e] NR = Not reported due to organic interference.

detectable levels of 2,3,7,8-TCDD. The reported 2,3,7,8-TCDD, CDD and CDF concentrations from the secondary copper smelter are one or more order of magnitude larger than any other source tested under tier 4, and as many as two to four orders of magnitude greater than concentrations from some of the sources.

A number of sources have considerably lower concentrations than the secondary copper smelter, but considerably greater concentrations than a number of other sources. On the other hand, some sources (e.g., kraft paper recovery boilers) have very low concentrations of 2,3,7,8-TCDD, CDDs and CDFs. For most sources the CDF concentrations appear to be closely related to those of CDDs, i.e., sources which emit higher concentrations of CDDs also emit greater amounts of CDFs.

4.4.1a Quality Assurance

The sampling and analysis in this study required the use of state-of-the-art methods. The stack sampling method is currently undergoing validation testing. Preliminary results indicate that recovery efficiencies from the sampling train may be low and variable. Analytical methods were not always able to cope with high levels of interfering contamination; thus, for some samples, the desired validity and precision of results was not achieved.

The stack gas samples collected at the secondary copper smelter contained such high levels of CDDs and CDFs that the sensitivity of the analytical procedures and equipment was reduced. Therefore, the results for this source represent minimum levels, and actual values could have been considerably higher.*

At the wire reclamation incinerator, the levels of concentration from other organic compounds in the sample were so high, even after rigorous laboratory extraction and sample cleanup procedures, that only estimates of CDDs and CDFs are available. At the wood stove site, it could not be determined if CDDs/CDFs were present in any of the three stack test samples due to similar organic contamination. No results were obtained from the mobile source exhaust samples because internal reference standards were not added to the samples prior to the extraction step in the analytical procedure. At a few other sites, relatively minor problems occurred with limited number of samples, but these did not affect the analysis or the overall integrity of the data.

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*Subsequent to the tier 4 test, the secondary copper smelter was retested by the source in conjunction with the State agency. This retest found CDD emissions to be one third of the tier 4 results while CDF emissions were 70 percent of the tier 4 values.

4.4.2 Results Reported in the Literature

The scientific literature was reviewed to identify combustion source studies that were similar in scope and measurement methodology to tier 4. CDD and CDF data for 17 sources in the U.S. and Canada are presented in Tables 4-4 and 4-5. These results have also been normalized to a 3 percent oxygen concentration.

Table 4-6 has been prepared to facilitate a comparison of these data with those obtained under the tier 4 program. The sources in Table 4-6 are listed in descending order of 2,3,7,8-TCDD concentrations.

Eight source tests (seven coal-fired boilers and one co-fired boiler firing fuel and refuse) reported in the literature had "non-detectable" stack gas concentrations of CDDs and CDFs. Pre-1986 data for municipal waste combustors (MWCs) are also provided.

4.5 Discussion of Stack Test Results

The determination of the ground level concentration includes the impact on dispersion of stack height, stack gas temperature, stack gas flow rate (i.e., the size of the source) and local meteorological conditions, in addition to CDD and CDF stack

TABLE 4-4. CDD EMISSIONS DATA FROM STUDIES SIMILAR TO TIER 4

(ng/dscm @ 3% O_2)[a]

Source	2,3,7,8-TCDD	Chlorinated Dibenzo-p-dioxin Homologues					
		Other Tetra-	Penta-	Hexa-	Hepta-	Octa-	Total[b] Tetra-Octa
Hazardous Waste Incinerator	1.4	64	8.3	1.3	1.1	2.4	77
Hospital Incinerator	ND[c]	ND	74	65	79	110	330
Municipal Carbon Regenerator	ND	0.01	0.13	0.37	0.47	1.6	3.3
Municipal Waste Combustors							
Plant A	0.7	10	NR[d]	26	12	4.1	53
Plant B	26	700	1600	1700	1600	860	6400
Plant C	NR	2.1	1.7	3.4	25	14	46
Plant D	0.8	30	250	210	200	15	710
Plant E	16	640	1700	1200	520	210	4300
Plant F	NR	7	18	36	58	90	210
Co-fired Boiler 80% Coal/20% Refuse	ND	ND	ND	ND	ND	ND	ND
Coal-fired Utility Boilers Seven Plants	NR	ND	ND	ND	ND	ND	ND

[a] ng/dscm @ 3% O_2 = nanograms per standard cubic meter of flue gas, normalized to 3 percent oxygen.
[b] Numbers across may not add up to totals due to rounding.
[c] ND = Not detected, generally at less than 1 ng/dscm @ 3% O_2.
[d] Not reported.

TABLE 4-5. CDF EMISSIONS DATA FROM STUDIES SIMILAR TO TIER 4

(ng/dscm @ 3% O_2)[a]

Source	2,3,7,8-TCDD	Chlorinated Dibenzofuran Homologues					
		Other Tetra-	Penta-	Hexa-	Hepta-	Octa-	Total[b] Tetra-Octa
Hazardous Waste Incinerator	2.1	170	12	4.8	0.81	0.24	190
Hospital Incinerator	NR[c]	130	220	200	120	65	735
Municipal Carbon Regenerator	0.02	1.4	1.1	0.76	0.76	0.72	4.8
Municipal Waste Combustors							
Plant A	NR	150	NR	100	12	1.0	260
Plant B	310[d]	3300	4200	2200	1600	120	11,600
Plant C	NR	14	9.4	15	56	22	120
Plant D	4	65	60	13	3	ND[e]	150
Plant E	57	1400	2100	1400	400	41	5300
Plant F	NR	38	63	78	62	12	250
Co-fired Boiler 80% Coal/20% Refuse	ND	ND	ND	ND	ND	ND	ND
Coal-fired Utility Boilers Seven Plants	NR	ND	ND	ND	ND	ND	ND

[a] ng/dscm @ 3% O_2 = nanograms per standard cubic meter of flue gas, normalized to 3 percent oxygen.

[b] Numbers across may not add up to totals due to rounding.

[c] Not reported.

[d] Only three of eleven tests conducted at this site reported 2,3,7,8-TCDF.

[e] ND = Not detected, generally at less than 1 ng/dscm @ 3% O_2.

TABLE 4-6. TIER 4* AND OTHER SOURCES LISTED IN RANK ORDER BY 2,3,7,8-TCDD CONCENTRATIONS
($ng/dscm @ 3\% O_2$)[a]

Source	2,3,7,8-TCDD	Total CDDs	Total CDFs
*Secondary Copper Smelter[b]	170	16,000	65,000
Municipal Waste Combustor - Plant B	26	6,400	11,600
Municipal Waste Combustor - Plant E	16	4,300	5,300
*Industrial Waste Incinerator	4.5	630	2,400
Hazardous Waste Incinerator	1.4	77	190
Municipal Waste Combustor - Plant D	0.8	710	150
Municipal Waste Combustor - Plant A	0.7	53	260
*Wood-fired Boiler	.28	200	83
*Sewage Sludge Incinerator - Plant C	.14	53	450
*Wire Reclamation Incinerator[b]	.07	440	580
*Sewage Sludge Incinerator - Plant A	.05	20	44
*Drum and Barrel Furnace	.05	5	27
Hospital Incinerator	ND[c]	330	735
Municipal Waste Combustor - Plant F	NR[d]	210	250
Municipal Waste Combustor - Plant C	NR	46	120
*Industrial Carbon Regenerator	ND	3.7	3.3
Municipal Carbon Regenerator	ND	3.3	4.8
*Kraft Paper Recovery Boiler - Plant C	ND	2.9	2.1
*Sewage Sludge Incinerator - Plant B	ND	1.6	28
*Kraft Paper Recovery Boiler - Plant B	ND	1.2	0.7
*Kraft Paper Recovery Boiler - Plant A	ND	0.7	0.6
Co-fired Boiler (coal and municipal waste)	ND	ND	ND
Coal-fired Utility Boilers (7 Plants)	NR	ND	ND

[a] $ng/dscm @ 3\% O_2$ = nanograms per standard cubic meter of flue gas, normalized to 3 percent oxygen.

[b] Data reported for this site are "estimated minimum". The true value may be higher.

[c] ND = Not detected, generally at less than 1 $ng/dscm @ 3\% O_2$.

[d] NR = Not reported.

concentrations. These parameters were entered into the dispersion component of the Human Exposure Model (HEM) to estimate the annual average ground level concentration in the vicinity of the source. In the application of this model to the tier 4 data, it is assumed that the CDD and CDF emitted from the stack is a gas. This assumption is believed to be a reasonable one for these sources. While different calculated ambient air concentrations could result from particle deposition, it is believed that such effects would not be significant because 1) these sources are generally low level emitters; and 2) the particle size is likely to be small enough that the effect of deposition on ambient air concentration will not be a significant factor.

As discussed in Chapter 1, EPA uses "2,3,7,8-TCDD toxic equivalency factors" (TEFs) to estimate the toxicity of other CDDs and CDFs. The TEFs for the various CDDs and CDFs were presented in Table 1-1. In applying the TEF approach, CDDs/CDFs for a particular homologue were assumed to be the most toxic isomer, thus yielding an upper bound estimate. The particular TEF values used in this tier are presented in Table 4-7.

The calculated maximum ground level concentration, estimated annual loadings, and 2,3,7,8-TCDD equivalents for the tier 4 sources and for most of the sources from the literature are presented in Table 4-8.* To place these results in some perspective, the cancer risk from inhalation exposure to a ground level concentration of 1 picogram per cubic meter of 2,3,7,8-TCDD equivalents is estimated at 3.3 chances in 100,000, assuming 70 years of continuous exposure. As with the stack concentration data, there is considerable variability among the various sources

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*Ground level concentrations were not calculated for the eight sources with nondetectable CDD/CDF emissions. Neither the hospital incinerator nor the municipal waste combustor, Plant F, are included in Table 4-8.

TABLE 4-7. RELATIVE POTENCY FACTORS USED IN ESTIMATING 2,3,7,8-TCDD EQUIVALENTS

Compound(s)	Relative Potency Factor
2,3,7,8-TCDD	1.0
Other TCDDs*	0.01
Penta-CDDs	0.5
Hexa-CDDs	0.04
Hepta-CDDs	0.001
Octa-CDDs	0.000
2,3,7,8-TCDF	0.1
Other TCDFs*	0.001
Penta CDFs	0.1
Hexa-CDFs	0.01
Hepta-CDFs	0.001
Octa-CDFs	0.000

* NOTE: In situations where 2,3,7,8-TCDD or 2,3,7,8-TCDF were not chemically analyzed in the sample, then TCDDs and TCDFs will have a relative potency factor of 1.0 and 0.1, respectively.

TABLE 4-8. TIER 4 AND OTHER SOURCES LISTED IN RANK ORDER BY 2,3,7,8-TCDD EQUIVALENTS[a]

Source	2,3,7,8-TCDD Equivalents (ng/dscm @ 3% O_2)[b]	Annual Average Maximum Ground Level Concentration[c] (pg/m^3)	2378-TCDD Equivalent Emissions (g/year)[d]
*Secondary Copper Smelter[e]	3900	1.5	800
Municipal Waste Combustor - Plant B	1400	9.1	500
Municipal Waste Combustor - Plant E	1300	1.5	140
Municipal Waste Combustor - Plant D	140	3.0×10^{-2}	95
*Industrial Waste Incinerator	130	1.2×10^{-2}	0.7
Municipal Waste Combustor - Plant A	56	0.3	80
*Wood-fired Boiler	29	6.1×10^{-2}	0.6
*Sewage Sludge Incinerator - Plant C	25	0.91	2
*Wire Reclamation Incinerator[e]	10	9.1×10^{-3}	1×10^{-2}
Hazardous Waste Incinerator	7.4	9.1×10^{-2}	2
Municipal Waste Combustor - Plant C	5.7	0.24	1×10^{-5}
*Sewage Sludge Incinerator - Plant A	1.3	3.0×10^{-3}	2×10^{-2}
*Drum and Barrel Furnace	1.2	6.1×10^{-5}	9×10^{-3}
*Sewage Sludge Incinerator - Plant B	0.52	1.2×10^{-3}	4×10^{-2}
*Industrial Carbon Regenerator	0.31	3.0×10^{-4}	2×10^{-2}
Municipal Carbon Regenerator	0.20	1.5×10^{-3}	4×10^{-5}
*Kraft Paper Recovery Boiler - Plant C	0.12	1.5×10^{-4}	0.3
*Kraft Paper Recovery Boiler - Plant A	0.01	3.0×10^{-5}	3.0×10^{-2}
*Kraft Paper Recovery Boiler - Plant B	<0.01	3.0×10^{-5}	3.0×10^{-2}

* Sources tested by Tier 4.

[a] Isomer-specific data are generally not available. Homologue data are considered to be composed of the most toxic isomers.

[b] ng/dscm @ 3% O_2 = Nanograms per standard cubic meter of flue gas, normalized to 3 percent oxygen.

[c] Ground level concentration calculation assumes compounds are present at analysis detection limits when reported as not detected (ND).

[d] Assumes 8160 operating hours per year.

[e] These values are estimated. True values may be higher.

for all three of these parameters. In general the sources with the highest stack concentrations of 2,3,7,8-TCDD, CDDs and CDFs also had the highest ground level concentrations. One notable exception is the sewage sludge incinerator, Plant C. Stack concentrations at this plant are about two to three orders of magnitude less than those of the secondary copper smelter, yet the ground level concentrations from the two sources differ by less than a factor of two. The sewage sludge incinerator has a relatively low stack with low temperature flue gas coupled with a high plant throughput, which leads to a relatively high ground level concentration impacting a small area very near the plant. On the other hand, the secondary copper smelter has a relatively tall stack with high temperature flue gas which results in a comparable ground level concentration, but at a significantly greater distance from the plant. The area impacted by this concentration is much greater.

In addition to estimating ground level concentrations, EPA has prepared a preliminary assessment of the potential cancer risks from inhalation associated with emissions from these facilities. A detailed discussion of the risk assessment is not included in this report due to the concerns raised by EPA's Science Advisory Board (SAB) during its review of the study. The SAB cautioned that risks were likely to be higher than estimated if exposure pathways other than inhalation were considered (e.g., food chain), and if more sources had been tested. EPA agrees with these comments and is currently developing a procedure to consider the risks associated with secondary pathways of exposure. Further testing of other sources may be considered as the Agency moves forward with its ongoing effort to decide whether CDDs/CDFs should be listed as hazardous air pollutants.

Tier 4 stack test program results and preliminary risk assessments have been provided to appropriate State air pollution control agencies for their information and use.

4.6 Tier 4 Ash Sampling Results

Three different types of samples were collected: bottom ash, fly ash, and scrubber water effluent. Bottom ash is the residue left in the combustion chamber as a result of the combustion process. Fly ash is the material collected by air pollution control devices which would otherwise be released to the ambient air. Scrubber water effluent samples are samples obtained from wet scrubbers, an air pollution control device which uses water to filter both particulate and gaseous pollutants from the exhaust gas stream.

Ash sample results for the 72 tier 4 sites are summarized in Tables 4-9 and 4-10. Table 4-9 presents data from the source categories with detectable values of 2,3,7,8-TCDD equivalent while Table 4-10 is a listing of the source categories where 2,3,7,8-TCDD equivalent was not detected in the ash. A total of 87 samples were analyzed from the 72 sites.

CDDs and CDFs were found in about one-third of the bottom ash and fly ash samples and one-half of the scrubber effluent samples. The highest concentrations were typically found in fly ash samples. Ash samples were collected from 21 different source categories. Twelve of the source categories had one or more ash samples with detectable concentrations.

It is presently difficult to interpret the significance of the ash data from an air pollution perspective. One of the objectives of the study was to determine a correlation between fly ash and stack emission concentrations. While the presence of CDDs and CDFs in the fly ash appears to be a good indicator of the presence of CDDs and CDFs in the stack emissions, no quantitative relationship has yet been observed that could reliably predict the magnitude of CDD/CDF emissions in the stack gases.

TABLE 4-9. TIER 4 ASH SAMPLING RESULTS

Source Category/Source Sampled	Sample Type	2,3,7,8-TCDD Equivalent (ppb)
Wire Reclamation Incinerator		
Source-C	Fly Ash	656[a]
Source-A	Fly Ash	87
Source-A	Bottom Ash	32
Source-A	Fly Ash	21
Source-A	Bottom Ash	4
Source-B	Fly Ash	0.3
Source-D	Fly Ash	ND[b]
Secondary Copper Smelter		
Source-B	Fly Ash	117[a]
Source-A	Fly Ash	13
Wood Fired Boiler		
Source-A	Fly Ash	158
Source-C	Fly Ash	135
Source-B	Fly Ash	51
Source-D	Scrubber Effluent	0.1
Source-A	Bottom Ash (2 Samples)	ND
Source-E	Fly Ash	ND
Source-F	Fly Ash	ND
Source-G	Fly Ash	ND
Source-H	Fly Ash	ND
Municipal Waste Combustor		
Source-C	Fly Ash	142
Source-D	Fly Ash	44
Source-B	Scrubber Effluent	4
Source-B	Scrubber Effluent	3
Source-B	Bottom Ash	0.3
Source-C	Scrubber Effluent	0.1
Hazardous Waste Incinerator		
Source-B	Scrubber Effluent	42.9
Source-A	Bottom Ash	ND
Source-C	Scrubber Effluent	ND
Carbon Regeneration Furnace		
Source-C	Fly Ash	18
Source-A	Fly Ash	0.1
Source-B	Scrubber Effluent	ND

TABLE 4-9. TIER 4 ASH SAMPLING RESULTS (continued)

Source Category/Source Sampled	Sample Type	2,3,7,8-TCDD Equivalent (ppb)
Sewage Sludge Incinerator		
Source-C	Scrubber Effluent	8
Source-F	Scrubber Effluent	5
Source-B	Bottom Ash	0.1
Source-A	Bottom Ash	ND
Source-C	Bottom Ash	ND
Source-C	Scrubber Effluent	ND
Source-D	Scrubber Effluent	ND
Source-G	Bottom Ash	ND
Source-H	Bottom Ash	ND
Source-I	Bottom Ash	ND
Source-J	Scrubber Effluent	ND
Industrial Waste Incinerator		
Source-A	Bottom Ash	2
Commercial Boiler		
Source-B	Fly Ash	1
Source-A	Fly Ash	ND
Hospital Incinerator		
Source-D	Fly Ash	0.9
Source-B	Fly Ash	0.6
Source-A	Bottom Ash	0.4
Source-D	Bottom Ash	0.4
Source-C	Bottom Ash	ND
Drum and Barrel Furnace		
Source-B	Bottom Ash	0.5
Source-E	Bottom Ash	0.3
Source-C	Bottom Ash	0.2
Source-A	Bottom Ash	ND
Source-B	Bottom Ash	ND
Source-D	Bottom Ash	ND
Apartment House Incinerator		
Source-A	Bottom Ash	0.3
Source-B	Bottom Ash	0.1
Source-C	Bottom Ash	ND
Source-D	Bottom Ash	ND

[a] These values are estimated. The true values may be higher.

[b] ND = Not detected, generally less than 0.08 ppb.

TABLE 4-10. TIER 4 ASH SAMPLING RESULTS WITH BELOW DETECTION LIMIT ASH SAMPLE RESULTS[a]

Source Category Sampled	Number of Samples		
	Fly Ash	Bottom Ash	Scrubber Effluent
Charcoal Grill	-	1	-
Charcoal Manufacturing Oven	2	1	-
Kiln Burning Hazardous Wastes	3	-	-
Kraft Paper Recovery Boiler	5	-	-
Open Burning/Accidental Fires	-	2	-
Small Spreader Stoker Coal Fired Boiler	3	1	-
Sulfite Liquor Boiler	-	-	4
Utility Boiler	3	-	-
Wood Stove	-	3	-

[a] Detection limit generally less than 0.08 ppb. Listed alphabetically.

Table 4-11 provides a comparison of the data from sources with both fly ash and stack test samples. This table illustrates the apparent lack of correlation between the two types of samples. For example, the secondary copper smelter, which had significantly higher stack concentrations than any other source, has fly ash concentrations more than an order of magnitude lower than some other sources. Other sources with relatively low stack emissions had fairly high fly ash concentrations. At this time, ash data do not appear to be a reliable indicator of the relative magnitude of CDD/CDF emissions in the stack. Fly ash samples, on the other hand, are believed to be fairly reliable indicators of the presence of CDDs/CDFs in stack emissions.

The ash sampling results have been transmitted through EPA's Regional Offices to the appropriate State and local agencies for their consideration. Although of limited usefulness for air pollution control purposes, the data do provide a measure of the level of contamination in the ash that is disposed of as a solid waste.

4.7 Findings and Conclusions

This investigation included a review of information in the literature and a sampling program for the combustion source categories believed to have the greatest potential to emit CDDs and CDFs. The findings from this investigation are presented below.

(a) CDDs and CDFs have been detected in the stack emissions from most, though not all, combustion source categories tested to date. All of the sources stack tested under tier 4, and most of the combustion source categories tested by others reported in the literature, had detectable concentrations of CDDs and CDFs.

(b) There is considerable variability in the emission rates among source categories. For example, measured CDD emissions ranged more than four orders of magnitude from "nondetected" at seven coal fired power plants tested (detection limit at less than 1 ng/dscm) to approximately 16,000 ng/dscm of total CDDs at

TABLE 4-11. COMPARISON OF ASH AND STACK EMISSIONS AT SOURCES WITH CONCURRENT MEASUREMENTS

Source	2,3,7,8-TCDD Equivalents	
	Fly Ash (ppb)	Stack Emissions (ng/dscm @ 3% O_2)[a]
Wood Fired Boiler	158	29
Municipal Waste Combustor - Plant C	142	5.7
Secondary Copper Smelter	13	3900[b]
Industrial Carbon Regenerator	0.1	0.31
Kraft Paper Recovery Boiler C	ND	0.12
Kraft Paper Recovery Boiler A	ND	0.01

[a] ng/dscm @ 3% O_2 = Nanograms per standard cubic meter of flue gas, normalized to 3 percent oxygen.

[b] These values are estimated. The true values may be higher.

a secondary copper smelting facility. Most of the combustion source categories fell within an intermediate range, generally two to three orders of magnitude less than the concentrations at the secondary copper smelting facility.

(c) EPA has not yet determined the magnitude of the potential population risk from these sources. An effort is underway to consider risk from all routes of exposure (e.g., inhalation, ingestion, dermal contact) and for evaluating procedures for estimating nationwide impacts from these sources.

(d) The presence of CDD/CDF in the fly ash from a control device appears to be a good indicator of the likely presence of CDD/CDF in the stack emissions. Presently, however, it does not appear that the ash samples can be used to reliably estimate the magnitude of CDD and CDF stack emissions from a particular source. Continued use of expensive stack test methods appears to be necessary.

4.8 Continuing Efforts

Although the tier 4 study has been completed, the Agency plans a number of continuing efforts with respect to CDD emissions from combustion sources. These include:

(a) A detailed technical report describing the tier 4 program is being finalized.

(b) EPA issued a report to Congress on July 1, 1987 responding to the requirements of section 102 of the Hazardous and Solid Waste Amendments of 1984 concerning CDD emissions from municipal waste combustors. This effort also identified design and operating guidelines to minimize CDD emissions.

(c) EPA has decided that additional Federal regulation of municipal waste combustor emissions is warranted under section 111 of the Clean Air Act. The regulatory determination was published in the Federal Register on July 7, 1987 (52 FR 25399).

(d) EPA plans to continue its evaluation of CDD/CDF emissions from various sources. EPA has not yet determined whether CDDs/CDFs should be listed as a hazardous air pollutant under section 112 or otherwise regulated under other sections of the Clean Air Act.

(e) EPA is continuing its efforts to standardize and refine stack sampling and analysis procedures to reflect improvements in the state-of-the-art. The recommended ASTM stack test methodologies for municipal waste combustors are currently being validated by the Agency.

Chapter Five

REGULATORY ACTIVITIES

EPA has issued regulations under the authorities of RCRA, TSCA, and FIFRA to control the generation, use, and disposal of many CDD/CDF containing materials and their precursors. This chapter reviews the highlights of several completed or ongoing regulatory initiatives.

5.1 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) LISTING OF DIOXIN CONTAINING WASTES AS HAZARDOUS WASTES (OFFICE OF SOLID WASTE)

EPA's rulemaking regarding dioxin containing wastes was published in the Federal Register on January 14, 1985, and became effective on July 15, 1985. The regulation designates as acutely hazardous a number of waste streams containing tetra-, penta-, and hexachlorodibenzo-*p*-dioxins and dibenzofurans:

- Wastes from the production or manufacturing use of tri-, tetra-, and pentachlorophenol and their chlorophenoxy derivatives.
- Wastes from the manufacturing use of tetra-, penta-, or hexachlorobenzene under alkaline conditions.
- Discarded, unused formulations of tri-, tetra- or pentachlorophenol and their derivatives.
- Wastes from equipment previously used for production or manufacturing use of tri- and tetrachlorophenol.

Residues from the incineration or thermal treatment of soil contaminated with the listed wastes are designated as hazardous rather than acutely hazardous.

Generators, treaters, storers, and disposers of the listed wastes are subject to stringent management and disposal standards:

- Generators are subject to the 1 kg/month exclusion limit, i.e., facilities generating more than 1 kg/month are subject to the listing.
- Incinerator and thermal treatment units must be fully permitted or be certified by the Assistant Administrator/OSWER as meeting the Technical Standards in 40 CFR Part 264. These units must demonstrate the "6-

9's" (i.e., 99.9999 percent) Destruction and Removal Efficiency (DRE) that is also required for PCB destruction.

- Land disposal facilities which plan to accept dioxin wastes must be fully permitted and must submit a Waste Management Plan with the permit application.

5.2 PCB TRANSFORMER FIRE RULE (OFFICE OF TOXIC SUBSTANCES)

5.2.1 Summary of the Rule

EPA recently strengthened its August 25, 1982, rule regarding PCB transformers by placing additional restrictions and conditions on their continued use. These requirements are intended to reduce the fire-related risks posed by the continued use of PCB transformers.

5.2.2 Background

Fires involving PCB transformers can cause the rupture of PCB transformers, the release of PCBs, and the formation and distribution of PCBs and toxic products of incomplete combustion. Products formed from the incomplete combustion of PCB dielectric fluid containing tetrachlorobenzene include 2,3,7,8-TCDF and 2,3,7,8-TCDD. When PCB transformer fires occur in or near buildings, building occupants as well as emergency response personnel, cleanup crews, and members of the general public can be exposed.

The PCB transformer fire rule established the following requirements:

(1) High secondary voltage PCB transformers (480 volts and above) configured in a network fashion and used in or near commercial buildings must be removed from use, placed into storage or disposal, disposed of, or reclassified to PCB-contaminated or non-PCB status by Oct. 1, 1990.

(2) PCB transformers can no longer be installed in commercial buildings after Oct. 1, 1985.

(3) PCB transformers used in or near commercial buildings (other than high secondary voltage network PCB transformers) must be equipped with enhanced electrical protection by Oct. 1, 1990, to avoid failures and fires from sustained electrical faults.

(4) All transformers must be registered with appropriate emergency response personnel and with building owners by Dec. 1, 1985.

(5) All PCB transformer locations must be cleared of stored combustible materials by Dec. 1, 1985.

(6) All PCB transformer fire-related incidents must be immediately reported to the National Response Center, and measures must be taken as soon as practically and safely possible to contain potential releases of PCBs and incomplete combustion products to waterways.

EPA defines commercial buildings to include all types of buildings other than industrial facilities and would include locations such as office buildings, shopping centers, hospitals, and colleges.

In addition, while EPA concluded that there are several substitutes for PCBs in electrical transformers, preliminary data indicate that chlorinated benzenes and perchloroethylene (both of which have been proposed as substitutes for PCBs) may also lead to the formation of CDFs and CDDs in combustion situations. EPA advised that the replacement of PCB dielectric fluid with materials which in fire situations may also lead to the formation of CDFs and CDDs should be carefully considered in light of the Agency's decision in this rule to place conditions and restrictions on the use of PCB transformers. EPA will evaluate the need for additional action should this type of substitution occur.

5.3 CANCELLATION OF REGISTRATION OF 2,4,5-T (OFFICE OF PESTICIDE PROGRAMS)

Registered in 1948, the phenoxy herbicides 2,4,5-T and silvex were used to control broad leaf weeds in or on forests, rangelands, pasturelands, orchards and other crop lands, homes and gardens, certain aquatic areas, and rights-of-way such as roads, railroads, and electric utility lines. In 1970, acting on the basis of animal tests showing potential teratogenic (birth defects) effects of 2,4,5-T, the U.S. Department of Agriculture halted uses of this pesticide in instances where there was a high exposure potential: home and garden, recreational areas, and aquatic sites. All food uses of 2,4,5-T, except for rice, were halted as well.

In February 1979, EPA took emergency action immediately suspending all use of 2,4,5-T and silvex herbicides on forests, pastures, and rights-of-way, and use of silvex on or around aquatic sites, homes and gardens, recreational areas, and ornamental turf.

All registrations for 2,4,5-T and silvex have now been cancelled.

5.4 AMBIENT WATER QUALITY CRITERIA DOCUMENT (OFFICE OF WATER)

Under the Clean Water Act (CWA), 2,3,7,8-TCDD is listed as one of the 65 compounds and classes of compounds which EPA is required to control in industrial effluents.

In support of this requirement, EPA has published an Ambient Water Quality Criteria Document (EPA, 1984a) for 2,3,7,8-TCDD. As specified in section 304(a)(1) of the CWA, this document reflects the latest scientific knowledge on the kinds and extent of all identifiable effects on health and welfare which may be expected from the presence of 2,3,7,8-TCDD in any body of water, including groundwater.

States use EPA's ambient water quality criteria in setting water quality standards. These standards take into account particular water bodies and their designated uses. State water quality standards are enforceable maximum acceptable levels of a pollutant in ambient water.

5.5 WOOD PRESERVATION PESTICIDES--PENTACHLOROPHENOL, CREOSOTE, INORGANIC ARSENICALS (OFFICE OF PESTICIDE PROGRAMS)

EPA rulemaking and a negotiated agreement requires phased reduction of the hexachlorodibenzodioxin (HxCDD) level in pentachlorophenol or its salts to 4 ppm. The 2,3,7,8-TCDD level in this chemical must be below the limits of detection using gas chromatography/mass spectrometry (GC/MS).

A number of additional use restrictions, handling requirements and public information provisions are also included in the document:

- All three chemicals are to be classified for Restricted Use Only by Certified Applicators except for brush-on treatment of inorganic arsenicals and except for creosote application on pilings, pole framing, and railroad ties. For the latter use, the applicator must complete an EPA-approved training course.
- Impermeable gloves are required for all uses, plus additional clothing and respirators in certain situations.
- Eating, drinking, and smoking are prohibited during application of all three chemicals.
- A teratogenicity/fetotoxicity warning is required on the labels for all uses of pentachlorophenol and related salts.
- Application of pentachlorophenol (or its salts) or creosote to interiors is prohibited.
- EPA will also require information on health effects, worker/user exposure, and effectiveness of protective measures.
- Industry will put into effect a voluntary Consumer Awareness Program, the focus of which will be the distribution of a Consumer Information Sheet containing safe use and handling recommendations regarding treated wood products. One recommendation is that treated wood shall not be used in contact with food, feed, or drinking water. Another is that creosote- and pentachlorophenol-treated wood not be used in interiors, with certain exceptions.

5.6 TSCA §4/§8 RULEMAKING (Office of Toxic Substances)

On December 19, 1985, EPA proposed a Dioxin/Furan Testing Rule in the Federal Register. This purpose of the rule is to develop information on additional chemicals which may contain CDDs/CDFs as well as those containing other halogens (e.g., brominated compounds). As previously discussed, EPA's National Dioxin Strategy focused primarily on 2,3,7,8-TCDD contamination associated with 2,4,5-trichlorophenol (TCP).

The proposed rule under section 4 of the Toxic Substances Control Act (TSCA) will require manufacturers and importers of 12 commercial organic chemicals to test for the presence of certain chlorinated and brominated dibenzo-p-dioxins and dibenzofurans. In addition, this testing will be required for 20 other commercial organic chemicals not currently manufactured or imported, should their manufacture or importation resume.

EPA also proposes, under section 8(a) of TSCA, to require manufacturers and importers of the 12 commercially produced chemicals to submit existing test data on contamination of these chemicals with CDDs or CDFs and to require similar information on the 20 other chemicals, should commercial manufacture or importation resume.

If data from the testing proposed under this rule, or other valid existing test data, show that these commercial chemicals contain CDDs at concentrations at or above specified levels, EPA proposes to require, with respect to the chemicals, the submission of: (1) production, process, use, exposure, and disposal data under section 8(a) of TSCA; (2) unpublished health and safety studies under section 8(d) of TSCA; and (3) records of allegations of significant adverse reactions both to the chemicals and to the CDDs/CDFs under section 8(c) of TSCA.

The chemicals proposed for testing are listed below along with their Chemical Abstract Services (CAS) registry numbers, where available.

CAS No.	Chemical name
79-94-7	Tetrabromobisphenol A
118-85-2	2,3,5,6-Tetrachloro-2,5-cyclohexadiene-1,4-dione
118-79-6	2,4,6-Tribromophenol
120-83-2	2,4-Dichlorophenol
1163-19-5	Decabromodiphenyloxide
4162-45-2	Tetrabromobisphenol A bisethoxylate
21850-44-2	Bis(2,3-dibromopropyl) ether of tetrabromobisphenol A
25327-89-3	Allyl ether of tetrabromobisphenol A
32534-81-9	Pentabromodiphenyloxide
32536-52-0	Octabromodiphenyloxide
37853-59-1	1,2-Bis(tribromophenoxy)ethane
55205-38-4	Tetrabromobisphenol A diacrylate

5.7 LAND DISPOSAL BAN EVALUATION FOR DIOXIN CONTAINING WASTES (OSW)

The 1984 Hazardous and Solid Waste Amendments to RCRA banned certain untreated dioxin-contaminated wastes from land disposal. In the November 7, 1986 Federal Register, EPA promulgated treatment standards for those wastes based on Best Demonstrated Available Technology (BDAT). For thermal treatment processes, BDAT for these wastes has been determined to be a destruction and removal efficiency (DRE) of 99.9999 percent ("6-9's"). Following treatment, residues may be disposed of in a permitted hazardous waste land disposal facility.

Due to the current lack of disposal capacity for these wastes, EPA has, as provided by law, extended the effective date of the ban for 2 years. In the interim, these wastes may be placed in fully permitted facilities. As of July 1987, no land disposal facilities have applied for permits to handle the affected wastes.

Chapter Six

RESEARCH

6.1 Introduction

Dioxin research at EPA began in 1970, when 2,3,7,8-TCDD was found to be a contaminant of the commonly used herbicide, 2,4,5-T. This research effort was generally limited to developing a methodology for detecting 2,3,7,8-TCDD in environmental samples. Additional impetus was generated in 1984, when Congress enacted legislation specifically directed toward this class of chemicals. The 98th Congress appropriated specific resources for dioxin research in human toxicity, disposal methods, and sampling quality assurance.

In response to Congressional concern, the Agency established a dioxin research program during FY'1984, under the framework of the National Dioxin Strategy.

The Strategy specifically charged EPA's Office of Research and Development (ORD) with the following tasks: (1) pilot testing of promising disposal/destruction techniques including a comprehensive study of binding characteristics of 2,3,7,8-TCDD to soils, and field validation of destruction techniques; (2) guidance in sampling and analytical methods for detection and quantification, including quality assurance; (3) conducting hazard and exposure assessment for site-specific risk assessments, including establishing exposure scenarios; and (4) evaluation of the bioavailability of dioxins for use in food chain models.

The Agency began its research program by focusing on the most toxic isomer, 2,3,7,8-TCDD. The scope of more recent research has expanded to include other isomers and related compounds such as chlorinated dibenzofurans. The Agency is also evaluating information on the toxicity of the brominated CDDs/CDFs.

By establishing an International Information Exchange under the North Atlantic Treaty Organization (NATO) Committee on Critical Challenges of Modern Society (CCMS), EPA has taken initiative to coordinate its research with that of other industrialized nations concerned with dioxins. The United States, the Federal Republic of Germany, and Italy are coordinators of this project.

There are four areas of EPA dioxin research: technology assessment research evaluates technologies for the control and ultimate destruction or detoxification of dioxins; monitoring research develops analytical methodologies and quality assurance procedures for identifying and quantifying dioxins within biotic and abiotic matrices; environmental effects research considers the fate, mobility, and effects of dioxins in the environment, and determines the uptake and bioavailability in plants and living systems; health assessment research develops both the methodologies and the data base necessary for evaluating human health exposure and risks associated with CDDs/CDFs.

6.2 Technology Assessment

Since the inception of this research program, the Agency has made significant progress in evaluating and refining techniques for cleanup of CDDs/CDFs and related compounds. This includes field work on detoxification of dioxin-contaminated soils using Potassium Polyethylene Glycolate (KPEG) reagents; field testing of the EPA Mobile Incineration System (MIS) at the Denney Farm site near McDowell, Missouri; *in situ* stabilization testing using portland cement and lime-treated asphalt; and an evaluation of the utility of surface mines as repositories for dioxin-contaminated soils. Controlled laboratory tests have shown that the white rot fungus, *Phanerochaete chrysosporium*, is capable of degrading 2,3,7,8-TCDD, DDT, lindane, PCBs, and other difficult to degrade halogenated organics.

EPA's Mobile Incineration System was designed and built to provide on-site thermal destruction of hazardous organic substances. The total system consists of: (1) major incineration and air pollution control equipment mounted on three heavy-duty semitrailers; (2) combustion and stack gas monitoring equipment housed within a fourth trailer; and (3) ancillary support equipment.

In 1983, trial burns were conducted in Edison, New Jersey on RCRA-listed surrogates, including di-, tri-, and tetra-chlorobenzene, and tetrachloromethane. Currently, the mobile incinerator is installed at the Denney Farm site near McDowell, Missouri, where tests were conducted using both clean soil and soil contaminated with surrogates similar to those employed in the earlier liquid waste tests. Tests using dioxin-contaminated liquid wastes and soils verified the destruction and removal efficiency (DRE) and the effectiveness of the control devices. Interim delisting guidelines were established and analyses were conducted on ash, treated soils, filter materials, and process/quench water. The analyses determined that the guidelines were attainable.

The dioxin trial burns were successful, with DREs exceeding 99.9999 percent. Particulate emission permit limitations (<180 mg/m^3 @ 7% O_2) were achieved in three of four test runs. The fourth run exceeded the prescribed limit slightly, possibly due to the accumulation of submicron-sized particles in the air pollution control system. The observed CO emission values (1.3-7.7 ppm) are equivalent to those from the best available incineration technologies and are indicative of very complete combustion (Combustion Efficiencies = 99.993-99.999 percent).

The trial burn data supported the issuance of Federal and State permits required for extended use of the system at the Denney Farm site.

As of February 1986, about 2 million pounds of dioxin-contaminated solids (including soil, drums, and trash) and about 18,000 gallons of 2,3,7,8-TCDD containing liquid wastes have been processed.

The KPEG chemical destruction technique was used successfully in the states of Montana and Washington to detoxify pentachlorophenol-oil (PCP) and spent solvent waste contaminated with dioxin.

A mobile treatment unit mounted on a 45-foot trailer was used to process 8,650 gallons of PCP wood treating chemical waste at the Montana Pole site in Butte, Montana, and 7,550 gallons of an oily spent solvent waste at the Western Processing site in Kent, Washington. These wastes were contaminated with as much as 120 parts per billion (ppb) of 2,3,7,8-tetrachlorodibenzo-p-dioxin and other CDDs/CDFs at levels as high as 125,000 ppb. No dioxins or furans were detected in the treated oil at limits of detection in the parts per trillion (ppt) range.

A battery of bioassay tests was used to ascertain whether KPEG by-products: (a) bioaccumulated in tissues of organisms; (b) caused cell mutations; or (c) caused immediate harm to fish or mammals. There was no evidence that the by-products were toxic in any of the tests performed.

6.3 Monitoring

At the onset of the program, the existing analytical capability was insufficient to routinely analyze a large number of samples containing dioxins. As previously discussed, the Agency has developed a collaborative network of three of its laboratories (ERL-Duluth, Minnesota; EMSL-Research Triangle Park, North Carolina; and ECL-Bay St. Louis, Mississippi), referred to as the "Troika". The Troika has significantly improved the Agency's analytical capability and has made a major contribution to the state-of-the-art of analysis of 2,3,7,8-TCDD and other CDDs/CDFs.

A pilot round-robin survey of trace analyses of CDDs and CDFs in adipose tissues has been completed. Such methods will allow more accurate characterization of 2,3,7,8-TCDD exposure by measuring actual body burden.

A monoclonal antibody to detect and measure dioxins has been produced with sufficient specificity to warrant further characterization. These and other rapid screening techniques show promise in terms of both sensitivity and selectivity in quickly determining the present (or absence) of 2,3,7,8-TCDD.

6.4 Environmental Effects

Environmental effects studies have shown that dioxins are very tightly sorbed onto soils and that both organic contaminant content and actual organic matter are important factors in controlling dioxin movement in soils and the degree of binding to the soil matrix. Recent studies indicate that in large chemical waste landfills and in wood preserving facilities, the physical and chemical properties of the soils are quite different from other sites previously studied, and the dioxins are much more mobile.

Bioavailability studies in laboratory samples of contaminated soils from Missouri and New Jersey have shown that differences in the bioavailability of 2,3,7,8-TCDD from these two soils correlate with its extractability. These differences may be related to the different compositions of the soils, the differences in the types of application of dioxin to the soil, and the residence time of dioxin on the soil. Thus, public health risks may vary between sites as a function of contaminants present and bioavailability from the matrix.

Uptake studies have shown that, in comparison to other isomers, 2,3,7,8-TCDD preferentially bioaccumulates in fish. Limited plant uptake studies are being conducted to verify hypotheses regarding dioxin movement into plants and thereafter into food chains. Uptake studies of dioxins by large animals will also evaluate food chain contamination to humans through animal products.

EPA has also developed exposure assessment methods for 2,3,7,8-TCDD for five scenarios through which humans could be exposed to dioxin. Nomographs were developed for approximating upper bound carcinogenic risk. In addition, the risk assessment methods used by EPA for 2,3,7,8-TCDD were assembled and contrasted to those which were adopted by CDC and FDA.

6.5 Health Assessment

ORD has completed the Health Assessment Document for Polychlorinated Dibenzo-*p*-Dioxins, which provides a comprehensive multimedia assessment of the analytical methodologies, environmental levels, and ecological and health effects of four chlorinated dioxins. A similar document is being prepared for 2,3,7,8-TCDF.

An ongoing pharmacokinetic study of 2,3,7,8-TCDD in rhesus monkeys will provide results on distribution, accumulation, depuration, and transfer of 2,3,7,8-TCDD in offspring. A battery of immunological tests to analyze the results of exposing female rhesus monkeys and their offspring to 2,3,7,8-TCDD is also being developed.

Short-term *in vitro* bioassays and chemical analytical techniques for specially synthesized higher chlorinated CDDs and CDFs are being developed for comparison to *in vivo* animal assays. These *in vitro* assays will be evaluated with regard to their usefulness in providing complementary information or in serving as surrogates for *in vivo* toxicity assays. Lack of sufficient exposure information is often the reason that a causal relationship cannot be drawn between an agent and a human effect.

NIOSH/CDC Mortality Study of Exposed Workers

NIOSH has included 14 sites in a dioxin registry. Approximately 7,000 workers have been identified, and standard methods of followup are being used. Inclusion in the registry requires company records showing worker assignment to 2,4,5-T, 2,4,5-TCP, or pentachlorophenol processes. Demographic data have been coded for all workers, and the coding of detailed work histories is in process. Discussions of the chemical process and job duties have been completed at all but one site and have been initiated for the remaining site. Data have been collected on analytic measurements of dioxin in products, wastes, and process streams. This information is being used in the construction of the exposure matrix for the study. Completion is expected in 1988.

In addition to an Office of Health Research contribution to begin the registry in FY'84, Superfund resources are being provided to the register for a 3-year period that began in FY'84.

NIOSH/CDC Morbidity Study

In November 1986 NIOSH initiated a study of occupationally exposed workers at 2 of the 14 plants covered in the dioxin registry. The study was designed in cooperation with the States of New Jersey and Missouri and is being conducted with Superfund resources.

Blood serum analysis procedures recently developed by CDC will confirm exposure and establish body burdens. Review of medical records and testing during medical examinations will investigate a number of health end points. Results will be compared to a control group of unexposed people from workers' current neighborhoods. The study is scheduled for completion in 1990.

Because actual exposure to 2,3,7,8-TCDD has been confirmed through blood sampling, this study may provide much needed information on the human health consequences of 2,3,7,8-TCDD exposure.

Missouri Health Effects Studies

CDC conducted an immunological study of residents of the Quail Run Mobile Home Park, Gray Summit, MO, where contaminated oil was used to control road dust. Results were compared with those from a group of residents of other mobile home parks where no contamination was found. Some members of the high risk group did not respond to skin test antigens (anergy). Of those that did respond, positive reactions were obtained for fewer antigens than in the unexposed group (relative anergy).

Unfortunately, there were significant methodological flaws in the study (nearly 50% of the data had to be discarded due to interpretation problems). Further, there was no demonstrated association between observed effects and clinical manifestations of illness.

Several other dioxin-related studies have been conducted or are underway in Missouri including the adipose tissue study discussed in Chapter 1, a reproductive outcome study, and comprehensive physical examinations of residents of Quail Run Mobile Home Park.

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